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Association

CURRENT CLIMATOLOGICAL ACTIVITY IN ALBERTA

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FORWARD

The Alberta Climatological Association (ACA) continues to promote the exchange of scientific and technical information on climate activities in Alberta. Individuals and agencies, both private and public, are encouraged to share their climatological experiences and concerns. The general theme of climate activities in Alberta has brought forward a very interesting and diverse selection of technical papers for this 10th Anuual General Meeting of the ACA.

The Keynote address to open the General Meeting dealt with the relatively new area of marketing climatology. This topic indicates that climate related concerns are becoming more important to a wider and more diverse group of Albertans. Later, as part of the Technical Session, a paper was presented on the related issue of climate applications and their worth. The remainder of the technical papers considered areas encompassing agriculture, forestry and special applications such as the 1988 Olympic Winter Games.

A new addition to the proceedings this year is an inventory of climatological research which has been compiled by Alberta Environment. This is a very important part of the ACA mandate to provide information to the membership. Projects outlined in this summary provide members with an indepth view of the activities of the many agencies in Alberta that are conducting climatological research. The Executive was also very pleased to introduce to the membership the Alberta Climatological Association's newsletter, the General Circulation. It is intended that the newsletter will be used to communicate climatological information and concerns.

Publication of these proceedings was made possible by the allocations of funds from Environment Canada. Special thanks are extended to Dr. A. MacPherson of Environment Canada for his continued support of the ACA and to the secretarial staff of Research Management Division of Alberta Environment for their assistance in the preparation of the proceedings. Also, the assistance of the Executive, the speakers and all of the participants is greatly appreciated.

Bruce Thomson, Chairman

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Marketing Climatology for Today's Climate User

David W. Phillips[1]

1. Introduction

I am pleased and honoured to have been asked to speak to you at the opening session of the Alberta Climatological Association's tenth annual meeting. I have always been impressed with the activities and longevity of the ACA. The early work of Dick Longley, Ed Stashko and John Powell in promoting climatology in Alberta and continued growth and work of the Association during the 1980's are the prime reasons for the more enlightened viewpoint of what climatology is all about in this Province. Several years ago I tried to convince the Ontario-based Friends of Climatology to adopt a more formal existence similar to the ACA, using your constitution as a model. Their reluctance to do so is the principal reason why the Friends is more often a non-group and why the Ontario Regional Climate Advisory Committee is barely alive and well.

In a few minutes, I will speak about marketing climatology. If that conjures up a hucksterism image in your mind, consider the broader, popular meaning that says marketing has something to do with needs assessment, user research, product development, and distribution besides the familiar activities of selling, promoting and public relations. But first I will discuss the evolution of the climate user, the types of climate products and services, and the value and importance of climate data and information.

For most of this century, climatology was largely an academic subject. In most national meteorological services climatologists were busy looking after networks of stations, collecting, correcting and publishing data and producing "average" temperature and precipitation values, to be used in response to requests from the public. A few decades ago, however, climatologists began to develop the applied side of meteorology. Computers took the drudgery out of data handling and provided the climatologist with the opportunity and the means to supply better and more useful services and applications.

Several well-publicized climate disasters during the past 10 years have clearly raised our consciousness about the significance and impact of climate variability and change. The assumption of climate constancy is no longer valid. The increasing interest in climatology all over the world, especially as it relates to the need for protection and planning of the human environment, is an encouraging sign that we may be entering an era of better understanding of what service climatology can provide.

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2. Profile of the Climate User

Everyone uses climate data and information in one kind or another. Users range from individuals to agencies. Individuals purchase bathing suits and flood insurance based in part on expectations of climate. Farmers invest in irrigation equipment and hail insurance. Homeowners budget funds for heating and air conditioning using past climate. Many plan vacations or retirement in the climate they prefer. All are users of climate information. Many top-level decision makers are also likely users of climate information - product designers, architects, engineers, policy analysts and retailers. Their needs may be greater and more sophisticated than the user who unconsciously applies climate knowledge.

With such diverse users, we find that the range and level of data and information needs varies widely. The magnitude of decisions involving climate information range from an individual with a few dollars to the nation with its billions of dollars. The importance of climate may be central or only peripheral to an issue. And, problems range from microscale, to macroscale to combinations of all scales.

The use of climate data and information has changed over time as has the science of climatology.

Many of traditional man's early operational decisions were climate related: the march of the seasons dictated tribal migrations, controlled the available food resources, and governed the beginnings of agriculture. Medicine men, seers, chieftans, and high priests were elevated to positions of prominence because the communities in which they functioned believed that these individuals could foretell the hardships and blessings of coming seasons. They were the original climate user.

With the invention of basic meteorological instruments came the scientific application of the knowledge of climate. The first real system of climate data producer-user was in the 19th century with the transfer of knowledge from scientist to scientist. Initially, most, if not all climate data were used to compile averages of the climate of places. These data became part of the nation's climatological archive. Scientific man used climate to explain the distribution of global life zones and soil types. Geographers, biologists and educators wrote eloquent descriptions of regional climatologies relying heavily on the availability of expanding climatological archives.

The next era in the development and dissemination of scientific technical information occurred in the 1940s with the emergence of "big" science and technology. In changing direction following World War II, national meteorological services realized that the climatological archive could be used for planning in the medium and long term, such as in the design of transmission towers, the siting of hydro dams and the planning of

residential areas and recreational facilities. In these examples the information flow was from climate specialist to engineer, architect and designer. Consultation was more complex and information more sophisticated than earlier applications.

Today's climate user wears many hats. In many ways, he is the traditional man, the classical man, and the scientist/researcher. In addition he or she may be the community spokesman, policy analyst, social scientist, lawyer, economist, legislator, environmentalist or resource-minded person. Today's user needs information in many different forms and combinations. He's demanding, technologically acute and information thirsty.

Most users require concise summaries, many are after risk and design statistics and a few desire near real-time data. All expect information to be intelligible, convenient, high quality, meaningful and easy to interpret or input. An increasing few want to access climate data directly, from their office or home, and are anxious to have the data available for analysis on their micro-or mini-computer.

For a nation so greatly affected by the extremes of its weather, there is surprising unawareness in Canada of the enormous economic and social advantages to be gained by the proper application of climate information. Why do potential users ignore climate information? What are the major impediments to the use of climate information?

Of those who don't use climate information, there are those who feel they know all there is to know. They see climate as static, unchanging and only one of many other, more important variables to consider. At the other end, there are those who feel that climate is too complex, uncontrollable and abstract. There is nothing you can do about it, you are already locked in, i.e. the crop is already sown. Still other skeptics have reservations about the availability, utility, cost, value and (in the case of climate prediction) accuracy of the information or may have problems interpreting probabilistic data. Table I shows the results of a questionnaire of Illinois respondents who indicated why they/their company did not currently utilize climate information (Lamb, et. al. 1984).

All these reasons point to a lack of appreciation of climate information and its use in decision-making. This lack of use has in turn led to a lack of progress in acquiring climate data, and its analysis over the past several decades. Removing these barriers will produce a more effective use of climate information.

Table 1

Percent of respondents who do not use climate information for whom this non-use is due to the listed individual reasons. Some respondents gave more than one reason for their non-use (Lamb, Sonka, Changnon, 1984)

Historical Data:	Percent
- this information is not available	65
- no value even when believed to be available	42
- too costly to convert to a useable form	19
Year-to-date accumulations:	
- no need for it	54
- not available	43
- too costly	8
- not available when needed	27
Climate Predictions:	
- no need for information	28
- not accurate	73
- not available soon enough	13

3. Climate Products and Services

A way of enticing decision makers to use climate information is to make it easier for them to get the information. Useful, transferable and relevant climate information will also increase its frequency of use and range of possible applications. A full spectrum of material from historical time series analysis to the state of developing climate anomalies now and into next season could be made available and desirable to users.

3.1 Risk and Design Data

Assessing the risk of occurrence of many climate events is reasonably straightforward where there exists a substantial past record. In this regard, the climatologist is in an enviable position compared with data specialists in other fields. Climate risks and indices can be derived from historical and statistical data and such information is of great relevance in capital investment decisions such as the siting, design and construction of buildings and facilities.

The Canadian Climate Centre publishes climate risk data in several forms. These include the following examples:

(i)	Data Periodicals:	Principal Station Data summaries Data abstracts on microfiche Storm Rainfall Canada
(ii)	Atlases:	Climatic Atlas Climatique - Canada Rainfall Frequency Atlas for Canada Solar Radiation Data Analyses for Canada
(iii)	Interpretive Studies:	An Analysis of Solar Radiation Data for Selected Stations in Canada; Wind and Ice Loading in Canada; New Look at Ground Snow Loads in Canada; Climate Information for Building Design in Canada; Wind Data Energy Analyses for Canada.

These are several new challenges for climatologists to make better use of archive data to produce design information than has been done in the past. For many operational purposes, novel approaches are needed to utilize short-term weather forecasts to meet the requirements of specific applications. New data acquisition systems, eg. remotely-sensed data (satellites, radar) should be investigated and combined with conventional climate data acquisition methods.

3.2 "Now" Information

A new category of climate information use is the monitoring of in-season or current conditions. Such information use involves not only the year-to-date accumulations (heating degree-day totals, seasonal snowfall), but also the "now-only" conditions (e.g., mid-July soil moisture, late April soil temperature) that are typically contributed to by year-to-date accumulations of several meteorological parameters.

Now information permits the timely and productive adjustments to operating practices that are needed because of prior climate developments. This monitoring also leads to revised estimations of both the procedures that should be used during the rest of the season and their likely outcomes (including yields). Particularly prominent in this regard are agribusiness decisions relating to seed variety and planting rate, pesticide type and application, and harvesting/processing arrangements.

The Canadian Climate Centre carries out several monitoring activities. The Centre publishes weekly and monthly editions of Climatic Perspectives. More than 1300 subscribers receive up-to-date information on temperature and precipitation anomalies, forecasts and climate data in map, tabular and text form.

Also in monitoring, the Canadian Climate Centre is currently processing near real-time water budgets for approximately 300 synoptic stations across Canada. Because the water budget information (evapotranspiration, soil moisture, snowpack etc.) is available within 36 hours after the end of each seven-day period, it is particularly useful in climate monitoring and in those economic sectors requiring timely climate information, such as the identification of potential drought and spring flood areas, support for water supply forecasting in several basins and for forest fire prediction and management. To a large extent, the value of these products lies in their timeliness, through direct mail or in Climatic Perspectives or through direct assess via a remote computer terminal with a telephone modem.

The CCC has also completed development on the Palmer Drought Index. Beginning in Spring 1986, drought index maps will be issued weekly for the Prairie Provinces.

A new genre of climate analysis has emerged from the development of convertible software and mini and personal computers. Easy to use, interactive, menu-driven climate analysis software has been developed for the CCC to produce tabular, graphical and chart form summaries of meteorological and sea-state data. Two examples of this software are MAST (MArine STatistics) and LAST (LAst STatistics) for production of univariate and bivariate tabulations and graphs compiled from observations over water and land. The systems are accessible via telephone modem.

3.3 Climate Forecasts

Climate forecasts for a month or a season ahead are generally the product most eagerly desired by the public. The potential economic benefit from these forecasts may be much greater than that from the short-term forecasts.

Techniques for predicting climate anomalies, for next month and next season, have yet to demonstrate convincingly any degree of skill or reliability. The longest running climate forecast is NOAA's monthly and seasonal forecasts, however, their forecasts yield only marginal accuracy in estimates of the probability of the deviation of temperature change from normal and hardly any in precipitation. There is no skill in forecasts for periods beyond a season. However, White (1980) believes there is good scientific reason for expecting a systematic but gradual improvement in the accuracy and credibility of climate predictions. From all indications, credibility is essential because long-range forecasts could lead to unnecessary actions and expenses. In the survey of Illinois agribusiness users (Lamb, et.al., 1984), 3/4 of the respondents indicated that climate prediction would have to be "approximately correct 70-80% of the time before it could be incorporated into their decision-making process."

There are however, some situations where improved predictability may even now be possible. The duration, intensity and extent of drought is

highly dependent on known antecedent conditions. Cumulative climate events such as snow melt floods, water levels and ice concentration are reasonably predictable far in advance. Certain persistent meteorological events such as blocking or El Nino lend considerable predictability to climate conditions (White, 1980).

At the Canadian Climate Centre, an experimental monthly and seasonal climate prediction project began in February, 1985. National maps of temperature and precipitation predictions for the coming month or season are prepared. The prediction takes the form of probability forecasts for above normal and below normal conditions. These experimental products are being provided to a selected list of 140 interested clients in other government agencies, universities and the private sector across Canada. Client feedback on format and utility of these products is an essential feature of the experimental phase. The predictions are developed using a combination of statistical and analogue techniques (Shabbar, 1985). The process is still rather subjective, but the end products represent the consensus view of several professional meteorologists. A comprehensive verification scheme is being developed and a thorough evaluation of client feedback will be carried out in 1986. If results are positive, the outputs (or their improved successors) will be issued routinely to the Canadian public.

4. Benefits from Climatology

4.1 Assessing Benefits Derived from Climatology

Climate information is a basic requirement for a multitude of wide-ranging social, economic and planning decisions. With such an impressive array of climate services and products and with such a large number of ways in which the information can be used, it is surprising that relatively few are aware of the enormous potential and economic worth of using climate data and information. Until users become aware of the benefits they will remain unconvinced as to its utility.

Seldom to national weather services attempt to quantify, or in most cases even identify the economic and social impacts or cost of climate services, whereas there are several references on the economic value of weather services. Granted, it is difficult to assess the full value of climate information and services for several reasons. First, it is not enough to assess the purely monetary costs and benefits of a specific climate service; many of which cannot be quantified with precision. The valuations of the service, including quantitative and non-quantifiable social and personal payoffs are difficult to assess and would require extensive records and firm assumptions. Beyond this, cost-benefits of a program that itself seeks to disseminate information is impractical if not, impossible. Even if you could identify who uses information, it would be exceedingly difficult to assess precisely how much the information is worth. Instead we should seek to answer the broader question of whether the data we provide enables the user to analyze issues that are important to them.

Other reasons for the lack of evidence on the value of climate information relate to the pervasiveness and diffuseness of both users and uses (Changnon, 1982). Many users are the general public and it is not possible to define the economic value of knowledge in such a setting. And, climate information often produces secondary and intangible benefits that cannot be directly measured or located from market revenues, e.g., convenience, health, safety, comfort, effectiveness. At anything above the local scale, economic data are often not available and in the format required and for the compatible time period.

In partial fulfillment of my responsibilities as Rapporteur on Climate Applications for WMO Regional Association IV - North and Central America, I compiled several examples of studies that illustrate how different operational, investment and design decisions depend on climate information and services. Eight climate-sensitive sectors or activities were sampled including the major resource areas, recreation, building and construction, and transportation. What follows are selections of proven documentation taken from case studies in Western and Northern Canada:

(i) Three river diversion and dam projects near Winnipeg constructed between 1968-1972 cost $95 million. The estimated damages to the city of Winnipeg prevented by the construction of these works was put at $160 million in 1974 and $280 million in 1979 (Bowering, 1981).

(ii) Manitoba Hydro estimated losses of $80 million in power it was unable to produce and export due to deficiencies of snowcover in the spring of 1981. Credible climate forecasts would have allowed abnormally high water storage in the preceding season and relevant operating strategies to avoid the loss (Lawford, 1981).

(iii) In 1950 the Red River Flood caused $100 million (1950 dollars) damage in and around Winnipeg and necessitated the evacuation of more than 100,000 persons. Authorities built a series of hydrologic structures to minimize the effects of flood waters. In 1979 when the Red River rose to a water level fractionally higher than the mark in 1950 fewer than 10,000 persons had to be evacuated and losses to property were estimated at less than $10 million (personal communication).

(iv) A 1% improvement in the spring flow forecast at the Portage Mountain Reservoir in British Columbia could result in about a $1 million reduction in annual operational costs (McKay, 1976).

(v) A more accurate wind-load design for a communications tower in Alberta saved $55,000 in repair costs; while more accurate snow-load data for an area roof in Saskatchewan saved $25,000 (personal communication).

(vi) Parks Canada planners scrubbed plans to build a mechanical stairway from the Kluane Lake Basin to the Summit of Kluane Mountain Range at the cost of $1.5 million. Historical data indicated that the frequency of summer cloudiness would preclude viewing the spectacular ice fields 80% of the time (B. Findlay, personal communication).

(vii) Alberta monitors winter climate in order to advise skiers of best snow conditions. Some years favour cross-country skiing on the Prairie and in other years snow and temperature conditions benefit downhill skiers (Leggat, et al., 1981).

(viii) A valley bottom site was first selected for the Yukon mining town of Faro until climatologists pointed out the preference for a location 60 to 90 m above the valley floor to take advantage of milder temperatures within the slope of the Arctic inversion. Higher winter temperatures have resulted in lower fuel costs, fewer vehicle stoppages and higher people morale (Wahl and Hume, personal communication).

(ix) Delineation of areas where climate is suitable for special crops is an important application of climatology. For example, canola seed is a $224 million business (1976) in Western Canada where the prairie climate of hot sunny days and cool nights is ideally suited for intensive canola production. To the south the percentage of oil in the seed drops off so that growing it becomes uneconomic as far north as Minneapolis (McKay, 1984).

(x) Had the global drought of 1972 been predicted, Canada would not have constrained wheat production through the LIFT (Lower Inventories for Tomorrow) program and would have been able to sell the additional production at 1973 prices for a gain of about $1 billion (Williams, personal communication).

4.2 Documenting Uses of Climate Information

There is an important need to demonstrate through examples the economic usefulness of the services that climatologists provide to various human activities. Our charge is three-fold:

(1) to describe practical examples of successful uses of climate information

(2) to identify opportunities for productive use of climate information in long-range planning

(3) to produce practical information that can be readily understood and integrated into the decision making process.

If testimonials cannot be made, if opportunities cannot be generated, and if exciting new products cannot be produced, then there will be little motivation for investing in climate services or supporting network expansion and data exchange. To get funding it makes sense to ensure that the funding agency is receiving value for its investment. Morley Thomas put it best when he said:

"Most governments are looking for ways to reduce expenditures and if climatologists hope to obtain the resources necessary to contribute significantly they must draw attention to, and prove the worth or value of, their products and the necessity to use them in national planning" (Thomas, 1982).

This does not suggest that climatology is a panacea or that it is at the centre of the universe. On the contrary, it would be wise to market with a certain healthy realism that climatology offers good value and advantage not necessarily exactness and guarantee.

5. Elements of A Marketing Strategy

Several years ago, Wallen (1970) criticized many national meteorological services for being offices rather than services because they dealt with collecting and publishing data in a very general form but rarely provided data for specialized services that consumers wanted. He said that they often operated in isolation and were not able to capitalize on opportunities presented to them by users in providing services to planning and industries. Services are "mainly interested in promoting the purely scientific aspects of meteorology and climatology rather than fostering the development of meteorological applications" (Wallen, 1970).

His criticism was not necessarily, nor should it have been, directed at the Canadian weather service. Since World War II, our service has been at the forefront internationally of developing and promoting the science of applications climatology. The 1980s have already seen some significant changes in the way climate information was being marketed. Still, in spite of relatively aggressive education and public awareness campaigns, most users do not have an adequate understanding of what AES could provide, or how climatology could be used most effectively in various applications.

Next, consider two questions posed by Brad Schneller in an address to the Expert Committee on Agrometeorology meeting in 1984 (Schneller, 1985):

"If the potential value and cost benefit ratios are so impressive, why hasn't the adoption and use of this information by farmers been quicker and more widespread? Why haven't those who make or influence decisions directed more resources to climate and weather programs for agriculture?"

The questions reference farmers and agriculture but they could have been asked about any group or sector. Answers to these problems are not easily found; however, consider marketing as a possible solution.

I now return to the theme I began with when I implied that marketing was not merely a synonym for selling. In fact as Peter Drucker, one of the leading management theorists, said, "The aim of marketing is to make selling superfluous." There are several characteristics of an effective marketing orientation. They involve knowing the market, developing a product or service as a need not a want, packaging, distribution, and promotion.

5.1 Knowing Your Market

Public non-profit organizations must communicate with a wide diverse market. Consequently, their message is often weak, fails to describe the service adequately and cannot cite the benefits and value of the service in sufficient detail. While we must continue to provide services to all citizens on an equal basis, climatology must also begin to serve special groups with specific needs. Time and resource constraints necessitate a focused campaign to identify and work with markets, most sensitive to climate - utility companies, resource sector companies, and large municipalities - ones where the biggest payoff can be realized from enhancing the delivery and usefulness of information.

The National Climate Data Advisory Committee of the Canadian Climate Program has begun a pilot project to try and improve the sophistication of climate information/data usage by the Canadian insurance industry. Discussions with members of the Canadian Insurance Bureau and the Insurers' Advisory Committee have revealed some positive ways in which that sector can benefit from the right climate information.

There is an urgent need for better communications between climatologists and users of climatological data and information to ensure that the services supplied are those that are wanted and that users can make effective use of the information supplied. Our challenge is to break down the one-way, colonial style information flow. We don't necessarily know what is best for the user. Effective climate information needs user input to ensure its relevancy and transferability. On the other hand, users also need guidance in applying climate information effectively. In other words, we need to know each other better. We can do this by treading on each other's ground, participating in each other's courses and co-publishing in the popular literature.

In 1985, the Atmospheric Environment Service commissioned The DPA Group to study the total market for weather services and products in Canada, to recommend ways in which the content presentation and delivery of products and services could be improved and to communicate better the value of weather information to users and potential users. The focus was weather but most of the findings and conclusions apply to climatology as well (DPA, 1985). The DPA survey made it quite clear that AES lacks knowledge about the type of users and their needs for information in decision-making. Further, we were uncertain about which products each user utilizes and which contact in the user organization was responsible for co-ordinating the acquisition of weather and climate information. Even more damning, few user groups know what services AES does or could provide beyond public weather forecasts.

5.2 Product or Service

Much has been said already about climate products and services. Climate data and information are most unglamorous to the non-climatologist and unlikely to be supported in their own right. As Gordon McKay used to say,

"you can't eat, drink or bank climate." Yet, climate information is often vital in assessing the feasibility of food, water and economic projects.

Climatological information is saleable. The marketing prospects depends in large measure on how well the selling process is addressed. Climatologists must not forget to sell the value of their information.

DPA had this to say about our products, "there are too many products. Where possible these should be reduced in number, simplified and standardized." They went on to say that special products and special services should be differentiated by their localized focus, better content, tailored presentation (packaging), timely delivery and expert interpretation. Other product/service improvement possibilities include:

- re-doing traditional data summaries to make them more useable and understandable
- development of more indices eg., degree-days, climate severity index; and more secondary information eg. crop yields, forest fire potential
- update information on creeping disasters, eg., droughts and ice conditions
- information on impacts of climate and less reporting on non-significant extremes.

As stated above, these special products must be designed according to a client's needs - not produced first and sold second. Further, we must enlist climatologists who can work closely with new groups of users such as commodity dealers, marketing board officials, insurance brokers, financiers, chief executive officers, retailers, and others whose decision-making can be made more rational through climate planning.

Above all we must develop simpler and more digestible information. As information suppliers we have to compete with other information specialists for the valuable time of the decision maker. Clear, simple information will give one an advantage.

5.3 Presentation or Packaging

There is a general belief that the large amounts of published data and documents on such subjects as soil temperature normals, last week's provincial high and low temperatures, or regional climatographies end up on the shelf collecting dust. The conclusion is that the treatment and format of the subject is too complex or too detailed. Most users cannot understand what it is that is being provided. Further, they cannot afford the time to wade through countless copy, tables and figures. And most people don't get too excited about using mathematical equations and probabilities in management decision-making.

We must begin to prepare information that is pertinent, digestible, intelligent, convenient, timely and useful.

Another new challenge is to develop ways of integrating climate data with non-climate data and models eg. pollution, economic, crop yields, lake levels, etc. Our data must fit the spatial and temporal constraints of today's user.

5.4 Distribution

> *"It is often assumed that once information is available it naturally flows to useful outlets: in fact the reverse is much more frequently true - much of the world's knowledge lies unused behind dams of ignorance, indifference, and inefficiency"*

This comment, appearing in a brochure of the United Nations University, describes succiently the problem of information transfer. Indeed, producing, information is easy, getting it to where it's effective can be a lot harder. In the past the emphasis in climate services has been on producing data. We have underestimated the crucial link of distributing processed information to places of decision-making. Increasingly, emphasis must be directed at getting information to groups such as wheat growers in Saskatchewan, forest management officials in central British Columbia, international soybean buyers in Toronto, hydro-electric authorities in Quebec, apple growers in Nova Scotia, television crews in Montreal, oil drillers in the Beaufort.

Putting the range of information to any customer at the touch of a button creates a formidable marketing challenge. Permitting access ease to data is a way of making better use of it. New personal computer-based information delivery systems will be common place in the future. New technology for presenting information must constantly be assessed and tried. However, we cannot abandon some of the traditional information seeking habits e.g., publications, microfilm and face-to-face contact. Users must be the prime consideration in the development of any climate-based delivery system (Schneller, 1985).

5.5 Promotion

The future prospects for applied climatology depends in large measure on how well we promote the product. For if a product or service is rated as a need, not a want, then it is likely to be successful. We must work closely with users from the private and public sectors to increase their awareness of the need for climate information and the opportunities provided by the existence of climate data.

A program of education to improve the sophistication of their use of currently available products makes good sense and may be cheaper than

improving the scientific content of information. Once climatology is seen to be practical and profitable, users can be expected to make use of it quickly and widely.

The sell should be soft with publicity on the professional ability and competence of the climatologist and the potential benefits to be derived from specific applications of climate knowledge.

Conventional promotional means through glossy brochures, films, slide-sets and exhibits should be tried. In addition, on-site demonstrations to get potential users to adopt new or improved practices is worth trying. Also of promise are extension-type printed literature written so that farmers, business men and bureaucrats can believe in it and want the information.

6. Conclusion

Climatologists today have opportunities far greater than those of their forerunners. There is the challenge to continue to generate good climate data. But, the new challenge is to make maximum use of the opportunities that exist for government and society from climate information through marketing and effective public relations.

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TECHNICAL SESSION

SNOWPACK DEPLETION MONITORING IN ALBERTA USING COMPUTER-PROCESSED NOAA IMAGERY

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ABSTRACT

The utility of NOAA weather satellite imagery to monitor snowpack depletion in the Alberta Rockies was evaluated for the 1985 run-off season. Snow cover area estimates for the Bow River watershed above Banff were generated from A.E.S. digital NOAA imagery using an ARIES II image analysis system. Area statistics and map plots for a series of five cloud-free dates: May 1, 12, 17, 21, June 18, and July 3 resulted from one-dimensional thresholding of Channel 2 (Near IR) data. All imagery required considerable spatial and radiometric pre-processing, including image rotation, registration and haze correction. Initial testing confirms that this systematic approach can provide a suitable and consistent snow cover area index for input to watershed models used in river forecasting. In addition, a series of near real time NOAA-derived snow cover maps provided river forecasters with a better perception of the seasonal progression of snowpack depletion than the low-resolution small scale hard-copy images commonly available.

INTRODUCTION

The earliest satellite snow studies were attempted in the 1960's using rather crude TIROS-1 weather satellite oblique images. Cloud-snow discrimination problems became apparent and visual keys were developed to minimize these. Cloud-free image mosaics of large regions acted as rudimentary snow maps. Three improved satellite systems introduced in the early 1970's had application to snow cover mapping NOAA - National Oceanic and Atmospheric Administration, GOES - Geostationary Operational Environmental Satellite and Landsat (Barnes and Bowley, 1979).

While GOES imagery of North America is provided, on a normal basis, every half hour (McGinnis et. al., 1980) its 4 km resolution (visible band) is often considered too coarse for detailed snow mapping (Tarpley et. al., 1979). Landsat imagery, on the other hand, provides relatively high (80 m) resolution imagery, but at long (formerly 18) now 16-day intervals, considered inadequate to monitor a dynamic snow-depletion situation (Brown, Hannaford and Hall, 1979; Dillard and Orwig, 1979; Ostrem, Andersen and Odegaard, 1979). NOAA imagery seems to be a suitable compromise with its 1.1 km (VHRR/AVHRR) sensor resolution and two daily overpasses - morning and afternoon. (A complete description of the NOAA-TIROS system can be found in NOAA Technical Memorandum, NESS 95.)

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The vast majority of earlier snow cover mapping programs involved using a small-scale, hard-copy satellite image and a Zoom Transferscope or some similar device. With these, and relying on visual interpretations, image-derived snow areas could be manually transferred to base maps (McGinnis et. al., 1980: Brown and Hannaford, 1979). Lillesand et. al., (1982) describe difficulty registering severely-distorted imagery to a base map with this process, and Dillard and Orwig (1979) describe significant inconsistencies between image interpreters and their abilities to identify and map a reliable snow-line.

Rango, Salomonson, and Foster (1975) concisely summarize the requirements for real-time snow area monitoring:

> The early prediction of the amount of runoff to be derived from the snowpack allows more efficient utilization of the limited water supply for power generation, irrigation, flood control, domestic, and industrial water supplies and recreation.
>
> Observation of the areal extent of the snowpack has long been recognized as an important (but difficult to obtain) hydrologic parameter related to both the average snowpack water equivalent and the snowmelt-derived runoff.
>
> Remote sensing provides a reasonable way to monitor snow in remote regions and the data may even eventually be used to extrapolate conventional point data more effectively over entire watersheds. Some watershed numerical models are beginning to require the input of the observed snow-covered area. Satellite-derived snowcover seems to be a logical source for satisfying such requirements...

In 1985, the Alberta Remote Sensing Center and River Forecast Centre devised a pilot project that would test the application of digitally processed NOAA satellite data to mountain snowpack depletion and river forecasting in an operational context.

STUDY AREA

Snow cover area estimates were generated for the Bow River watershed above Banff, Alberta (Figure 1). The Bow River system is one of the more sensitive in the Province in terms of potential flood damage (to Calgary) and in terms of improving water management (power generation versus irrigation).

The study basin above Banff has a network of ground instrumentation which has been incorporated into the study. A snow pillow (pressure instrument for measuring snow water equivalent) is located in the basin at Sunshine Village and another just outside the basin near Mount Skoki. Snow course measurements are conducted at 10 locations in the basin each month, February to June. Temperature and precipitation data are available at Banff, Sunshine, Skoki, and several other locations. Streamflow is continuously recorded at the Water Survey of Canada hydrometric gauge in Banff.

The basin is 2210 km^2 in area, with glaciers at higher elevations covering roughly 4% of the basin area. Elevation ranges from 1372m to 3048m. Peak streamflow is normally in May or June as a result of snowmelt.

Figure 1. BOW RIVER BASIN

DATA ACQUISITION

Digital NOAA-6 and NOAA-7 images of the Bow basin were purchased from the Atmospheric Environment Service (AES) receiving station in Edmonton. On a weekly basis between May and July, 1985, the AES would vet the previous 7-days' imagery and select one cloud-free scene for the study. In all, six tapes with accompanying hard-copy (Vis.) images were subsequently processed:

May 1
May 12
May 17
May 21
June 18
July 3 (not integrated into the study)

The digital tapes were 3600', 16BPI, containing 3 channels of 8-bit data: Channel 2 "near IR" - called "Vis." by the AES staff - .725-1.1 micrometers: Channel 3 "middle IR" - 3.55-3.93 micrometers: and Channel 4 "thermal" 10.3-11.3 micrometers (NOAA-NESS, 1979). Channel 1 (.58-.68 micrometers) often used in similar snow-mapping applications (e.g. Lillesand et. al., 1982) was not made available for technical reasons. Each tape contained a lengthy swath of imagery (from the Arctic archipelago to northern Mexico) and usually extended from the Pacific Ocean in the west to Hudson Bay in the east.

DATA PROCESSING

For the purpose of river forcasting, a systematic, consistent, and high-resolution method of establishing snow covered areas (SCA's) was required. Digital image processing experiments at the Alberta Remote Sensing Center, using a DIPIX ARIES II LCT-II image analysis system began as the first of the series of NOAA tapes were delivered. The following procedure for determining snow-covered area was adopted:

1. Load Tape

The cloud-free NOAA tapes selected by AES staff were loaded in their entirety onto the ARIES image disk.

2. Determine Study Area

The whole image swath (Arctic to Mexico) was viewed on the video monitor and a generous sub-area representing the Alberta-British Columbia Rocky Mountain chain was extracted as separate image files.

3. Image Rotation

NOAA imagery captured during the ascending (northbound/afternoon) over-pass appears upside-down and the sub-area requires a computed inversion of 180° using a resampling algorithm.

4. Bad Line Repair

Further pre-processing was often required to correct "dropped pixels" or dark intermittent north-south oriented lines on the imagery caused by sensor interference. This required that the image be temporarily rotated 90° so that the pixels (columns) became lines (rows). New lines were created by averaging the lines above and below the bad lines. The sub-area was then rotated back with north "up".

5. Sub-Area Extraction

A second smaller sub-area was then extracted from the first. It included the study basin plus approximately a 30km radius of surrounding area. At this point, the image still retained significant geometric distortion and required digital rectification or registration to a map base. Then map-accurate outputs and reliable area measurements could later be generated.

6. Image Correction

Using a 1:250,000 topographic map of the study region, geographic control points (GCP's) that are visible on the map and on the imagery were selected. Notwithstanding temporal changes in the imagery due to snow depletion and solar illumination, points considered reliable as a control included large lakes and the intersections of distinguishable valleys. With a GCP file containing about nine points, the raw NOAA sub-sub area was registered to a U.T.M. base retaining its 1km resolution. Spatial accuracy estimates of the registration procedure range from <1 pixel inside the study area to within 2 pixels at the periphery of the sub-sub area based on visual 1:250,000 image plot and map overlays.

Only the first image of the series was registered to the map; subsequent images were registered to the first in the same manner.

7. Basin Delineation

Using a 1:250,000 image plot (with known UTM eastings and northings drawn-in) and a basin-topographic map (with the same UTM grid), the basin boundary was delineated in video using an electronic cursor. A "boundary" file was saved for use later to determine within-basin snowcover areas.

8. Atmospheric Effects

The only radiometric pre-processing conducted was to reduce (or eliminate) the variable lightening effects of atmospheric haze prior to image classification. An accepted method for so correcting multi-spectral or multi-date images is to shift band/channel histograms downward intact so that their darkest values are superimposed on a value corresponding to clear open water found on a near-IR band.

No sizeable, clear, open water bodies could consistently be identified on this NOAA images series, so each image was standardized to the darkest Channel 2 "land" value found on the first (1 May) scene. Therefore, even if any light haze was present on the "datum" scene, the data in subsequent scenes would be considered relative, and multi-date analyses valid.

9. Snow Classification

The development of a reliable and perhaps consistent "snow" signature over a time series of images formed the essence of this project. A multi-spectral (multi-channel) approach was initially considered to be the most rigorous and objective. Given that a somewhat linear correlation was identified over time between open snow pixel values in Channel 2 (near IR: albedo drops as water content increases during melt [McGinnis et. al., 1980]), and Channel 4 (thermal: temperature increases with melt), band ratio classfications were attempted, however unsuccessfully.

A literature review indicated a popular approach used some variation on digital density slicing/one-channel parallelepiped classification or more commonly "single band radiance thresholding". Experience with this method using Landsat imagery, (Dallam and Foster, 1975: Dillard and Orwig, 1979) and with NOAA imagery (Johnston and Hanssen, 1985: Ostrem, Andersen and Odegaard, 1979) seems extensive, though the procedures appear quite subjective (deriving signatures through numerous classification iterations and visual evaluations) only occasionally using coincident aerial photography as ground-truth.

This project's use of the near IR Channel 2 data for thresholding was primarily by default. Other researchers (e.g. Rango, Salomonson and Foster, 1975: McGinnis et. al., 1980) employed visible bands from NOAA or Landsat to determine total snow cover. Some literature indicated however, that high reflectivity of open snow cover in the visible bands can lead to image saturation (Luther, Bartolucci and Hoffer, 1975) which may cause overclassification of snow. In many other studies, authors were not explicit about which band or channel of satellite data they used.

Channel 2 of the 1 May U.T.M.-corrected sub-sub area (study basin plus surrounding territory) was loaded into the ARIES video. With file histograms and printed-out radiance values of pixels visually identified as open snow, the thresholds or "bounds" were iteratively developed. Snow, being the brightest feature on the cloud-free image, had no upper-bound constraint, so value 255 was used. The lower bound was established at 40 after atmosperic correction and after several trial classifications. It appeared that as the area above the tree-line dropped below value 40, the snow there had melted or ablated. Infrared radiance values corresponding to the emergence of green vegetation in the mountain valleys in the late spring, and obviously not snow, closely approached the 40 mark.

The 40-255 "signature" was applied to each subsequent Channel 2 image. Luther, Bartolucci and Hoffer, (1975) using visible and near-IR Landsat data, observed that the mean radiance values of open snow do not vary significantly between dates. No sun angle correction was incorporated, therefore, and no attempt was made to reconcile (and identify) discontinous snowpack or snow below the tree line. Few of the cited references were able to describe successes establishing and quantifying (spectrally and areally) such snow gradations and transition zones. Most researchers worked in either a vegetation-free environment (Ostrem, Andersen and Odegaard, 1979) or were quick to choose snow-no snow zones or classes in forested areas (Luther, Bartolucci and Hoffer, 1975; Johnstone and Hanssen, 1985; Foster and Rango, 1975).

After classification, each NOAA Channel 2 scene was merged with the basin boundary file to derive within-basin SCA statistics and graphics. Figure 2 shows the resultant outputs: a basin snow map and the percent covered by open snow that ranges from dense snowpack above the treeline and snow detectable just below the treeline early in May, to perennial glaciers and snowcaps in the early summer. Notably, this rather arbitrary snow signature appears to be consistent in suitably classifying open snow over a lengthy time interval (Ferner and Sutherland, 1986).

APPLICATION OF SCA DATA

1. Progression of Snowmelt

During the active snowmelt season, forecasters are often faced with the task of estimating the extent to which snow has been depleted on a watershed, and whether or not the peak runoff has passed. This is a difficult task without some form of field observation, be it either by human observer or instrumentation. An examination of this computer processed NOAA imagery gives Alberta forecasters a vivid near-real time sense of snow depletion trends and the extent of depletion with time. For example, in 1985, the peak streamflow on the Bow River at Banff was on 25 May. The extent of snow depletion from 12 to 21 May as evident from the images in Figure 2 would alert forecasters that peak runoff was approaching. Figure 3 illustrates the relationship between the NOAA SCA depletion estimates and the increase in gauged runoff at Banff during the project's time frame. Rango et. al. (1975) has shown that this relationship varies from year to year, as runoff is also dependent on variables other than snow covered area.

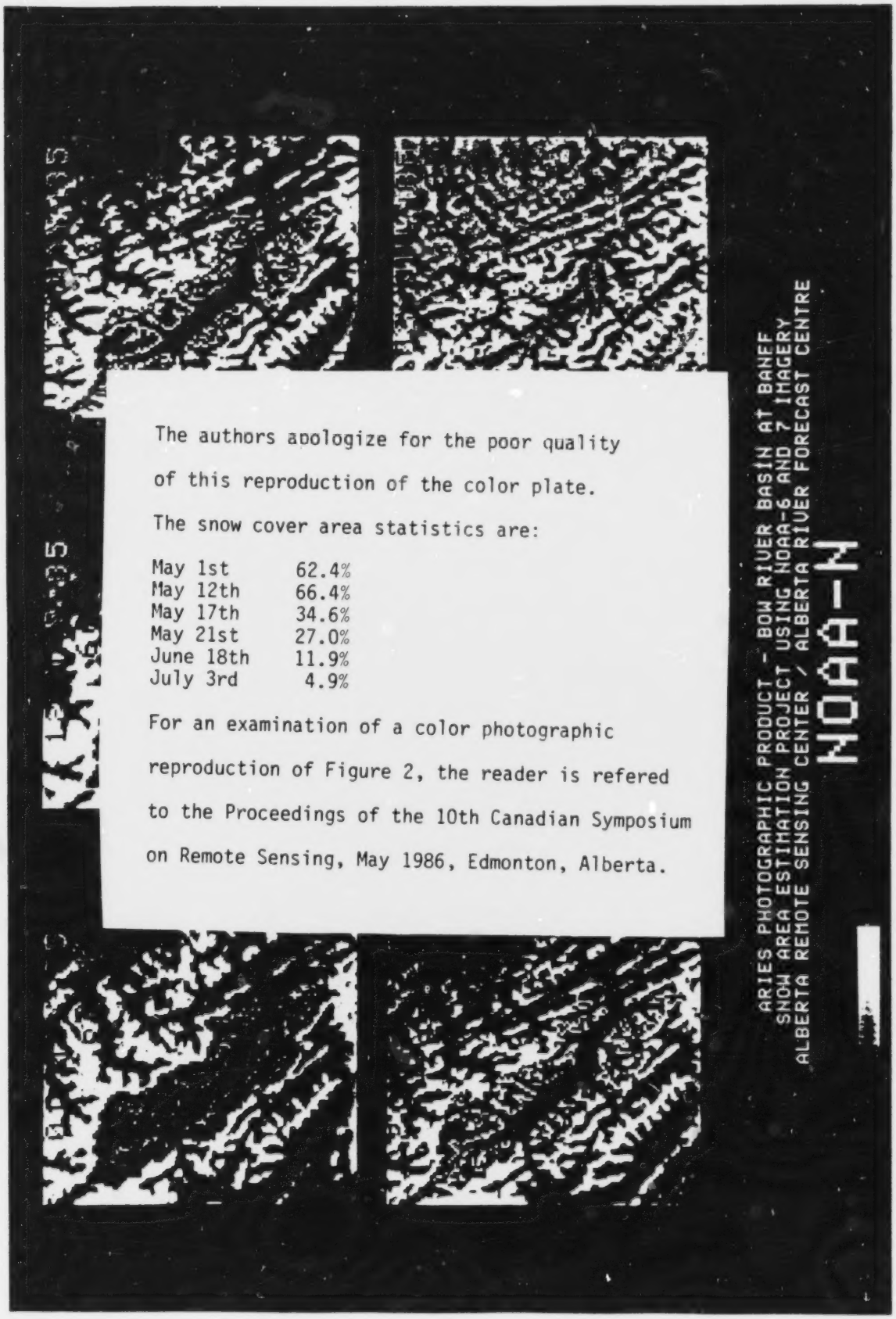
ARIES PHOTOGRAPHIC PRODUCT - BOW RIVER BASIN AT BANFF
SNOW AREA ESTIMATION PROJECT USING NOAA-6 AND 7 IMAGERY
ALBERTA REMOTE SENSING CENTER / ALBERTA RIVER FORECAST CENTRE
NOAA-N
The authors apologize for the poor quality
of this reproduction of the color plate.
The snow cover area statistics are:
May 1st 62.4%
May 12th 66.4%
May 17th 34.6%
May 21st 27.0%
June 18th 11.9%
July 3rd 4.9%
For an examination of a color photographic
reproduction of Figure 2, the reader is refered
to the Proceedings of the 10th Canadian Symposium
on Remote Sensing, May 1986, Edmonton, Alberta.

FIGURE 2. SNOW COVER AREA ESTIMATES FROM NOAA SATELLITE IMAGERY AS GENERATED BY THE ARIES II IMAGE ANALYSIS SYSTEM. THE RED AREA REPRESENTS THE SNOW PRESENT ON THE BOW RIVER BASIN ABOVE BANFF ON MAY 1, MAY 12, MAY 17, MAY 21, JUNE 18, AND JULY 3, 1985. PERCENTAGE OF THE SNOW COVERED AREA AS A BASIN AVERAGE IS ALSO PROVIDED.

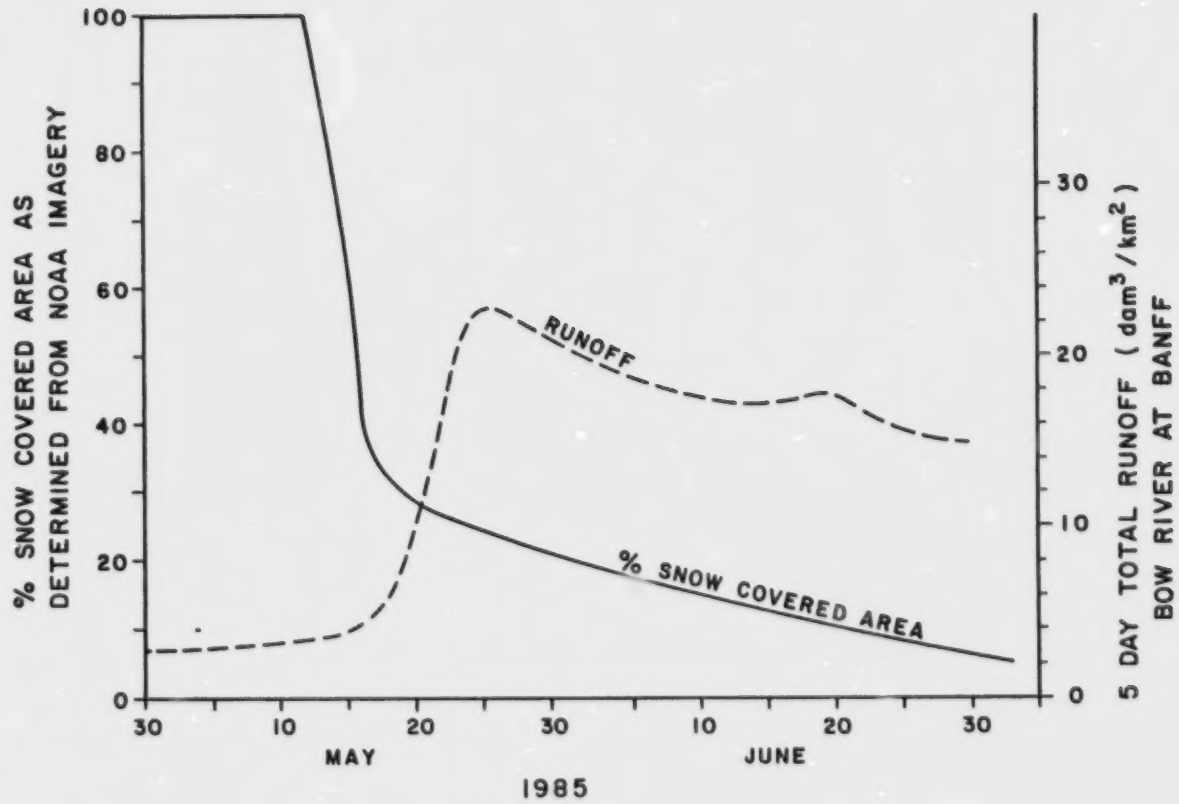

Figure 3. PERCENT SNOW COVER AREA VERSUS 5 DAY TOTAL RUNOFF FOR THE BOW RIVER ABOVE BANFF , 1985.

2. Indexing Snow Cover Depletion

The snow classification methodology applied in this study does not allow for the differentiation of cloud and snow on the image. For this reason, only clear sky images were evaluated. To mitigate such problems, a method to index SCA estimates during cloudy periods was developed. The relationship between accumulated melt at a high elevation snow pillow and snow covered area (Figure 4) can be used to estimate SCA during cloudy priods. The curve can be modified as more clear-sky images become available and are computer-processed.

The following table lists the number of clear-sky images over the Rocky Mountain chain which were available in May and June since 1982. NOAA imagery would have had limited application in 1984 due to cloud cover.

Year	Number of Clear Days Over Alberta Mountain Chain
1982	3 (May 10, 19, June 17)
1983	7 (May 10, 17, 18, 29, 30, 31, June 28)
1984	1 (June 11)
1985	5 (May 1, 12, 17, 21, June 18)

3. River Forecast Modelling

The River Forecast Centre is also experimenting with the integration of NOAA SCA's into its operational SSARR (Streamflow Synthesis and Reservoir Regulation) watershed model. Like Dillard and Orwig (1979), an "observed" variable such as that obtained from satellite imagery has been used to fine-tune the model, to better define total moisture available for runoff. Figure 5 compares the NOAA SCA's and those generated by the SSARR model. The general trend of early (May 10th to 24th) snow depletion is well matched. After May 24th, the SSARR model's peaks are responses to precipitation events which the model interprets as snow. A complete description of this experimental procedure is found in Ferner and Sutherland (1986).

DISCUSSION AND CONCLUSIONS

With the availability of a regular (at least weekly) supply of cloud-free imagery, dynamic snow depletion can be monitored in near-real time. Digital image processing significantly enhances the 1km resolution of NOAA data and can consistently identify and classify snow-covered areas to meet operational requirements for SCA estimates.

In addition to providing basin SCA statistics for watershed modelling, a graphic or visual product (e.g. Figure 2) can convey to forecasters the snow depletion situation in advance of stream gauge hydrographs.

The inability of this snow classification system to differentiate between cloud and snow, and interference from heavy haze or cloud cover are inherent problems which can be worked around. Only clear sky imagery can presently be used, but by indexing the snow covered area to measured melt at a snow pillow, the SCA can be estimated during cloudy periods in which suitable (cloud free) imagery is not available.

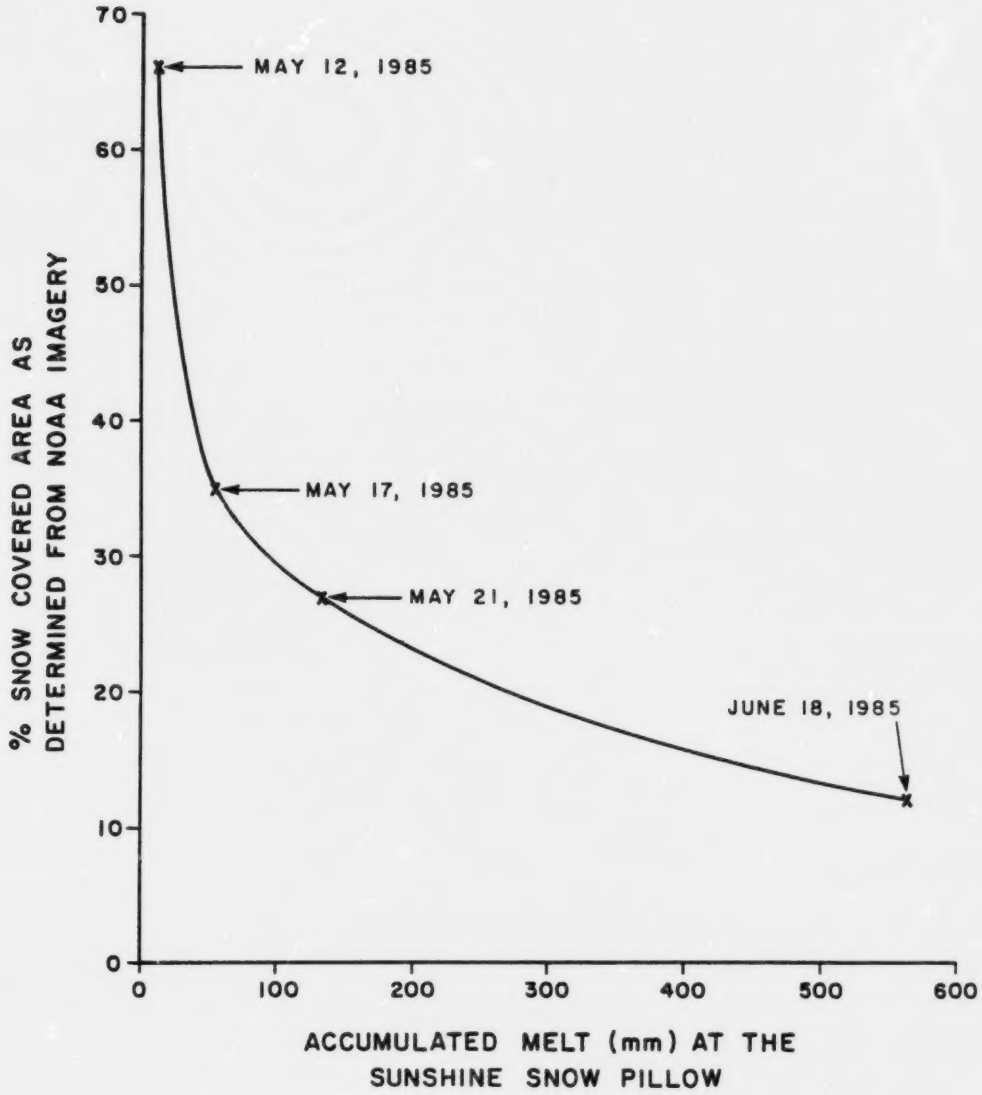

Figure 4. PERCENT SNOW COVER AREA vs ACCUMULATED MELT AT THE SUNSHINE SNOW PILLOW, 1985.

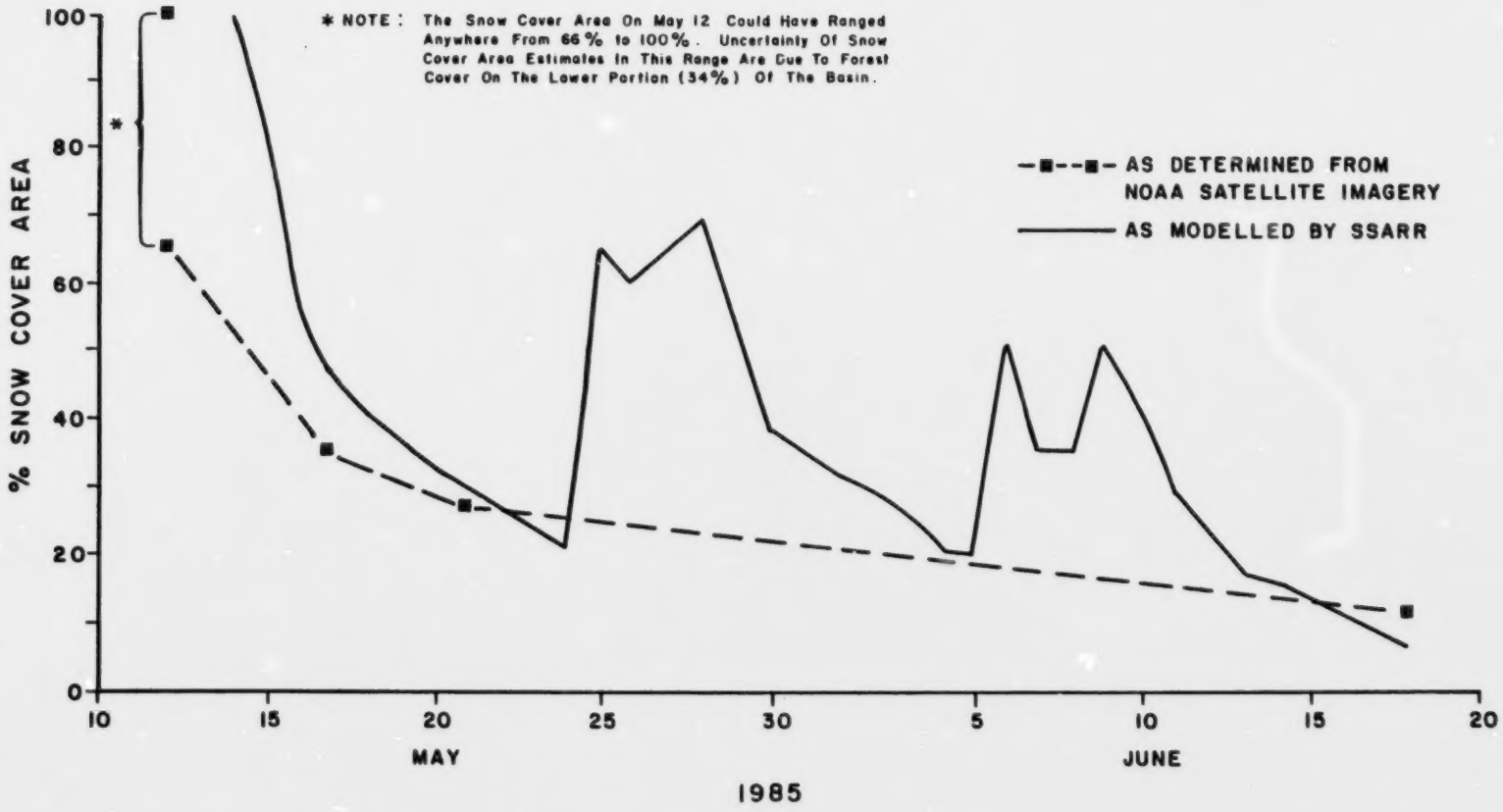

Figure 5. % SNOW COVER AREA vs. TIME FOR THE BOW RIVER ABOVE BANFF, 1985.

Interference from the forest canopy is a more difficult problem to resolve. Estimates of the SCA of the basin in this demonstration are those areas near and above the tree line, where open snow can be detected without being obscured by forest cover. Snow cover depletion in the forested portion of the basin (at least 34% of the total basin area) remains unknown. In 1985, peak runoff on the Bow River above Banff occurred after the snowline had moved above treeline.

Evaluations will be conducted on the assignment of an "annual" snow signature. First, the atmospheric correction may have to be based on the most cloud/haze free image in a date series - seriously reducing the statistical and graphic product turnaround time and compromising the near-real time aspect of the project. Second, the single-channel threshold approach to signature generation, despite an apparently suitable performance on the 1985 imagery, will have to be monitored closely and variations attempted as required. An historic imagery and runoff data base for the mountainous region of the province will be compiled. A few years of such processed imagery for the Bow River basin above Banff will be evaluated before procedures are applied to the other mountain basins in Alberta.

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The Effect of Selected Climatological Parameters on Yield of Barley and the Modification of Nitrogen Fertilizer Recommendations for Barley using Climatological Data.*

By

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ABSTRACT

Much research has evaluated the influence of selected climatic parameters on yield and nutrient composition of field crops in western Canada. These studies have recognized that the influence of fertilizer on yield is affected by climatic factors such as temperature and moisture. Several field experiments were established across Alberta in the 1970's with the objective of calibrating nitrogen soil tests with crop response to added nitrogen fertilizer. Recently, selected climatic variables were collected to derive an expression which describes crop response to nitrogen fertilizer and available moisture. Crop response was found to be significantly related to fertilizer inputs and available moisture. Yield increases were greatest when soil test nitrogen was low (< 7 ppm) and increased with increasing availability of moisture. Results suggest calibration of soil tests for nitrogen require some indication of available moisture.

Background

In the prairie provinces, soil testing services and soil fertility research agencies have long recognized that environmental factors play a significant role in the response of crops to applied nutrients.

Crop response to fertilizer nitrogen (N) is dependent on moisture supplies during the growing season. In the semi-arid regions of the prairie provinces the uncertain distribution of precipitation often makes the use of a specified amount of nitrogen fertilizer more

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profitable in some years than in others. Hence, the need to evaluate the effects of specific amounts of moisture and various rates of N fertilizer on yield response of crops.

Based on long term crop response trials at several locations, soil testing services establish a data base for making nitrogen fertilizer recommendations. In most cases, the recommendations relate crop response to soil test nitrogen levels in selected climatic areas. The procedure of relating soil test levels to crop response is often referred to as soil test calibration.

Recently, soil testing labs have begun the development of production models for making nitrogen fertilizer recommendations. Subsequently, the need to include climatological parameters into the models has become evident. For the purpose of calibrating nitrogen soil tests, climatic factors related to moisture and moisture availability are of greatest significance. The factors which are most commonly incorporated are:

- Soil moisture
- Growing season precipitation
- Evapotranspiration

Nitrogen fertilizer response curves and production models have recently been developed for the Manitoba Provincial Soil Testing Laboratory (Marantz and Racz, 1985 Personal Communication). These models have successfully incorporated parameters related to moisture availability into the Manitoba Soil Test Recommendation System. The objective of this paper will be to review the methodology and results in the development of the Manitoba models. In addition, the Soils Branch of Alberta Agriculture has begun the development of production models, using

some of the methodology developed in Manitoba. The applicability of the methodology to Alberta climatological data will be discussed and preliminary results will be presented.

Methodology

The calibration of the soil tests requires a statistical model to describe the relationship between yield, applied fertilizer, soil tests and selected climatic parameters. Statistical procedures for developing operational models for soil test calibration have been reviewed in depth (Colwell 1967b, 1967c, 1968). In general, multiple regression equations are used to relate independent variables such as soil tests to a dependent variable, in this case yield or yield response. Thus equations are a linear, or other combination of variables express as:

$$Y = b_0 + b_1(X_1) + b_2(X_2) + \ldots + b_n(X_n) \qquad (1)$$

in which X_1, X_2, ..., X_n are independent variables b_0 the level of Y when all independents are equal to zero (constant), and b_1, b_2 ... b_n are the variable coefficients.

In Manitoba, a number of climatic variables were combined to calculate a moisture variable for entry into the model (Eq. 1). In this case, the variable was SOIL WATER STATUS. The first step was to calculate potential evapotranspiration (PE). PE was calculated by the equation which was developed for limited climatological data (Baier and Robertson, 1968):

$$PE = 0.08636 * [0.928 * Tmax+0.933 * (Tmax-Tmin)+0.0486 * Qo-87.03] \quad (2)$$

Where: Tmax = Maximum temperature

Tmin = Minimum temperature

Qo = Solar radiation at top of atmosphere

PE = Potential Evapotranspiration

A biometeorological time scale (Robertson, 1968) was used to estimate stage of crop development:

$$\sum_{S2}^{S1}[a_1(L-a_0)+a_2(L-a_0)^2]\ [b_1(Tmax-b_0)+b_2(Tmax-b_0)^2+b_3(Tmin-b_0)+ b_4(Tmin-b_0] \quad (3)$$

Where: Tmax = Maximum temperature

Tmin = Minimum temperature

L = Photoperiod

a_0, a_1, a_2, b_0, b_1, b_2, b_3, b_4 = Coefficients

Consumptive use factors (Cu = AE/PE) (Actual evapotranspiration AE) were calculated based on stage of crop development and typically had values ranging from 0.3 at seeding to 1.0 at full ground cover. Seasonal water loss by evapotranspiration was then calculated as:

$$\text{Seasonal water loss} = \sum_{\text{Seeding}}^{\text{Harvest}} (PE)xCu \quad (4)$$

and actual water use by the crop calculated by:

$$\text{Crop water use} = \text{soil water (seeding)-soil water (harvest)} + \text{Precip} \sum_{\text{Harvest}}^{\text{Seeding}} \quad (5)$$

SWS was determined as being the difference between potential (Eq. 4) and actual (Eq. 5) water use.

Values representing SWS were then incorporated into Equation 1 and combined with soil test and fertilizer nitrogen levels to predict the response of barley. It was assumed that the available soil water reserve of the soil was 200 mm. In addition, as long as 100 mm of water remained, no moisture stress would occur. An SWS value of 0.0 was used to indicate the point above which no stress occurred. Negative values were used to indicate a moisture stress.

Summaries of barley response data from Manitoba from which equations were developed are presented in Tables 1 and 2. The data was grouped into relative ranges of SWS to determine the changes in barley response to nitrogen fertilizer under different levels of available water. These data show that response to nitrogen fertilizer is increased with increasing SWS and that the maximum yield attained is dependent upon availability of moisture. Figure 1 and 2 show generated response curves and calibration models developed from the data. The lowest curves represent a moisture deficit of 50 mm while the highest, a surplus of 150 mm. For the lowest curves, yield increases occurred only up to 60 Kg ha^{-1} of soil and fertilizer nitrogen. However, if SWS was at 150 mm, a barley response could be expected up to the 100 Kg ha^{-1} level of nitrogen supply. Equations relating soil test nitrogen, fertilizer nitrogen and SWS were highly statistically significant ($p < .0001$) and accounted for 80 and 84 percent of variation in experimental data respectively, depending on the variety of barley.

Although accurate for local conditions, models developed in Manitoba cannot be applied to climatic conditions in Alberta. For this reason, Alberta Agriculture began a re-evaluation of the Risk Adjusted

Table 1. Effect of Nitrogen Fertilizer and Water Supply on Yield of Conquest Barley

N-Added(Kg/ha)	Yield (Kg/ha)[1] Soil Water Status							
	-50.0 to 0		1.0 to 50.0		51.0 to 100.0		101.0 to 150.0	
	Non-Fallow	Fallow	Non-Fallow	Fallow	Non-Fallow	Fallow	Non-Fallow	Fallow
9	1326	2801	1805	3048	1527	3903	1888	4118
34	1576	2747	2010	2678	2123	3961	2480	4539
67	1883	2825	2486	2997	2854	4142	3148	4589
101	1981	2818	2628	2978	3151	4320	3499	4895
134	2163	2760	2690	3121	3427	4412	3695	4937
202	2326	2874	2963	3157	3564	4378	3896	4791
269	2373	2761	2924	3094	3476	4365	3862	4676
Mean Soil Available N (Kg/ha)	15	79	20	59	18	73	23	86

1. Yields represent means of all sites 1972-1975.

Table 2. Effect of Nitrogen Fertilizer and Water Supply on Yield of Fergus Barley

N-Added(Kg/ha)	Yield (Kg/ha)[1] Soil Water Status							
	-50.0 to 0		1.0 to 50.0		51.0 to 100.0		101.0 to 150.0	
	Non-Fallow	Fallow	Non-Fallow	Fallow	Non-Fallow	Fallow	Non-Fallow	Fallow
9	1470	3189	2009	3462	2056	4116	2090	4057
34	1783	3061	2535	3524	2582	4394	2639	4212
67	2121	3433	2905	3632	3273	4677	3518	4193
101	2476	3426	3243	3546	3446	4648	3719	4317
134	2549	3472	3300	3538	3560	4658	4148	4484
202	2797	3308	3514	3497	3673	4651	4079	4376
269	2878	3419	3236	3529	3508	4457	4204	4430
Mean Soil Available N (Kg/ha)	15	79	20	59	22	73	27	71

1. Yields represent means of all sites 1972-1975.

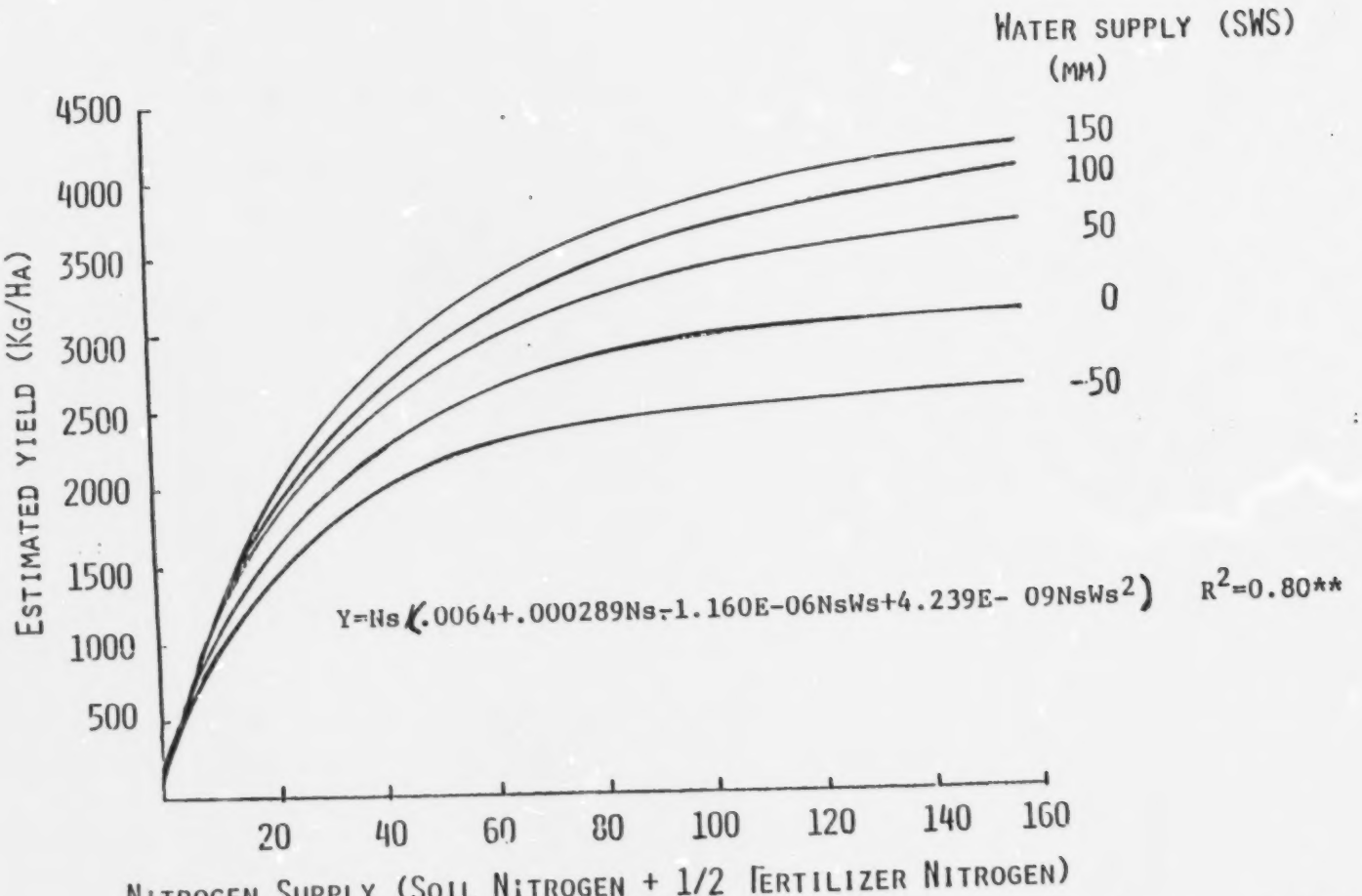

FIGURE 1. EFFECT OF NITROGEN SUPPLY AND WATER SUPPLY ON YIELD OF CONQUEST BARLEY.

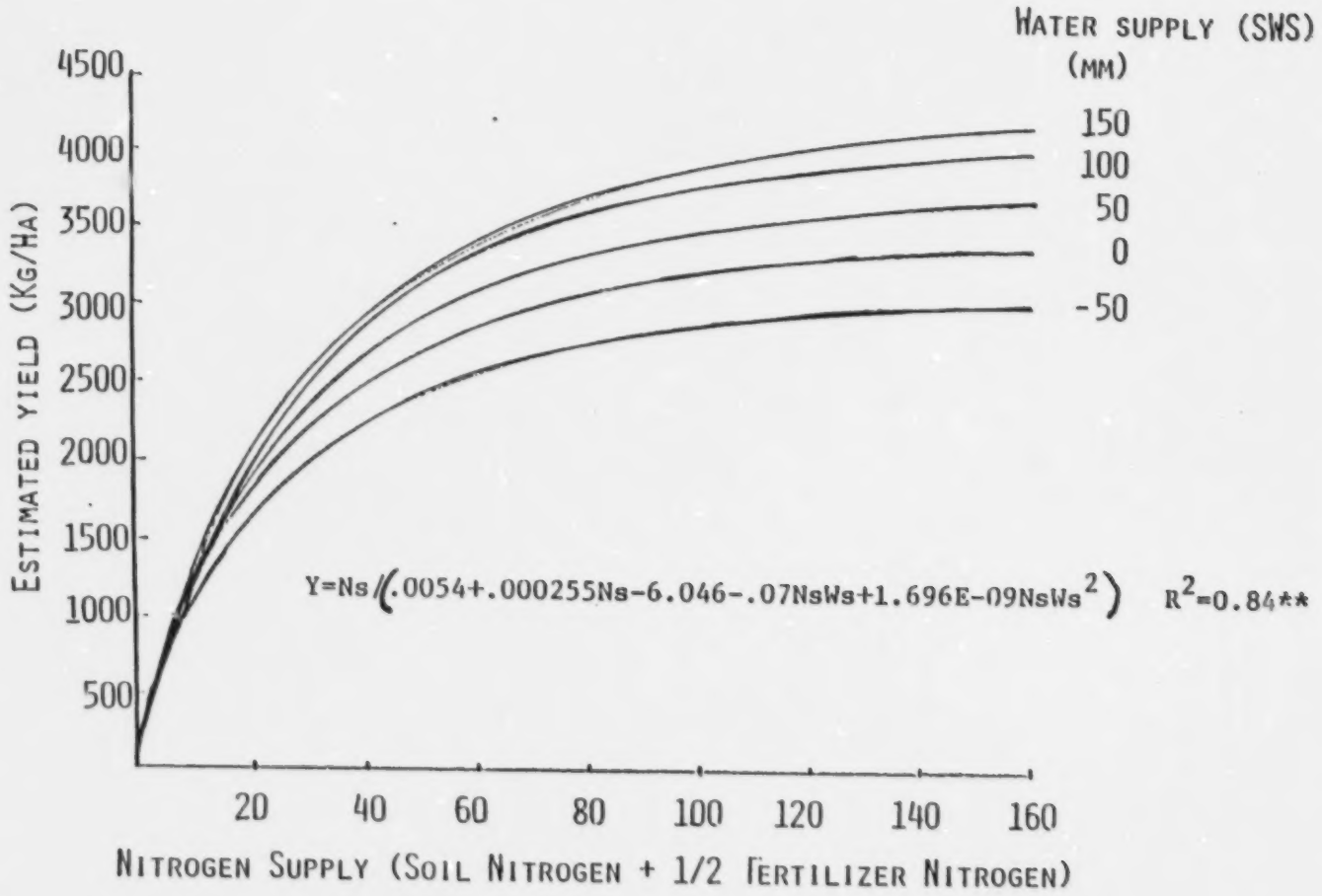

FIGURE 2. EFFECT OF NITROGEN SUPPLY AND WATER SUPPLY ON YIELD OF FERGUS BARLEY.

Yield Potential (RAYP) program to establish its potential to develop models similar to those developed in Manitoba.

The RAYP program consisted of experimental sites located at several locations over a four year period (1971-1974) to evaluate response of barley (c.v. galt) to nitrogen fertilizer. Areal distribution of sites in Alberta and soil locations indicating cropping history of the experimental sites are described in Figure 3 and Table 3 respectively.

Table 3. Numbers of Barley Plots on Fallow (F) and Stubble (S) for Each Year and Soil Group (RAYP 1971-1974)

Soil Group	1971		1972		1973		1974	
	F	S	F	S	F	S	F	S
Grey Wooded & Dark Grey, Fort Vermilion	0	0	2	2	4	4	4	4
Grey Wooded & Dark Grey, Peace River	3	3	2	1	1	0	0	0
Black and Dark Grey, Beaverlodge	1	0	1	0	1	4	0	0
Grey Wooded & Dark Grey Wooded, Central	2	2	2	3	1	3	0	5
Black & Thin Black, Central	5	16	8	26	7	20	1	11
Dark Brown - North of Bow River	3	0	2	0	2	2	0	0
Dark Brown & Thin Black, South of Bow	1	1	3	2	1	4	0	1

Distribution of experimental sites covered the majority of major climatic and soil areas of Alberta and most experimental sites were located in close proximity to climatological recording stations.

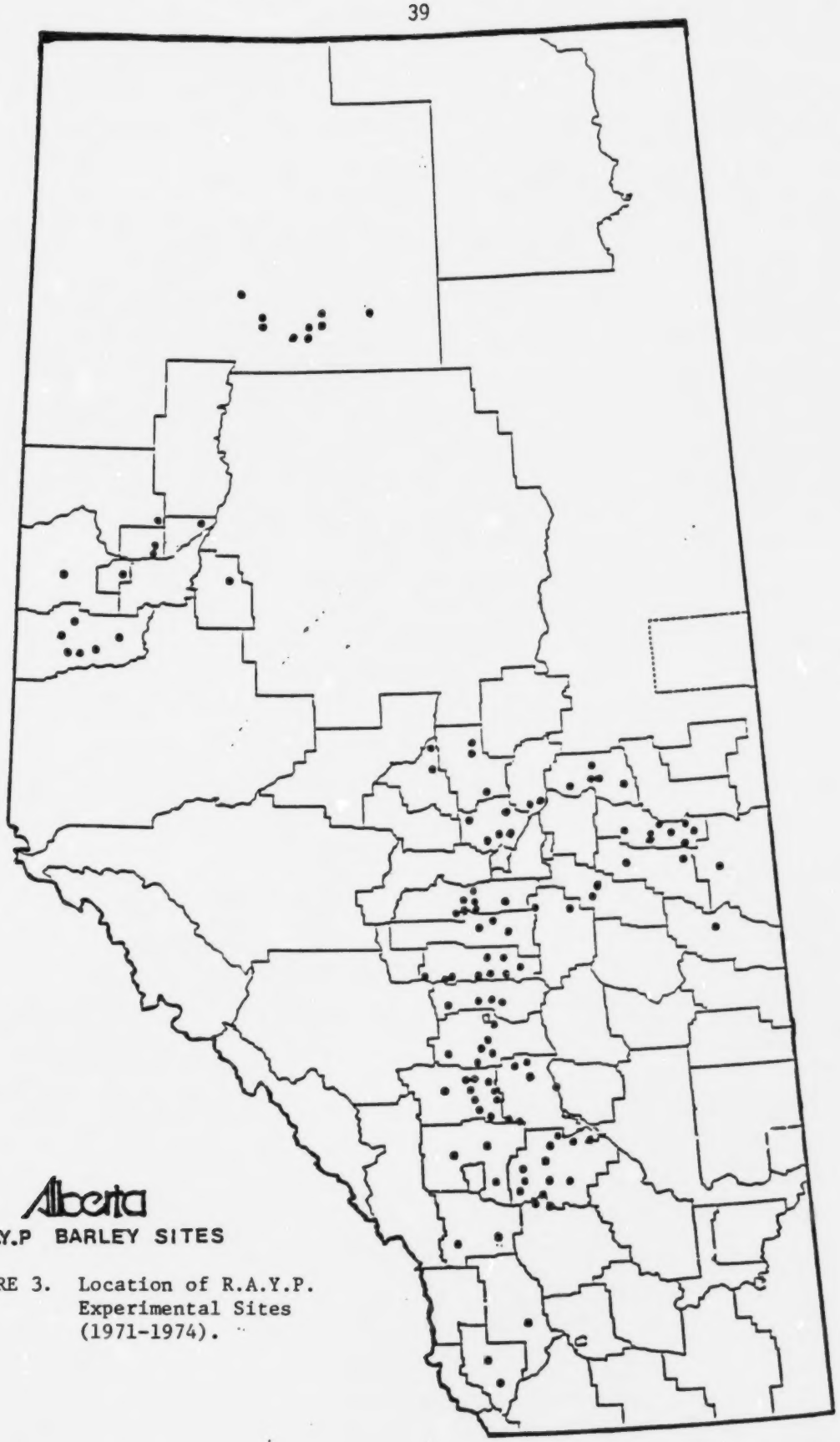

FIGURE 3. Location of R.A.Y.P. Experimental Sites (1971-1974).

Soil tests were conducted at each experimental site to determine soil nutrient levels at 0-15, 15-30, 30-60 cm depths. Nitrogen fertilizer was applied at rates of 30, 60, 90, 120, 150, 180, 240 lbs $acre^{-1}$. Grain yields were recorded for each treatment and location.

Results

A summary of barley yield response data by soil zone, over the four year period (1971-1974) is depicted in Figure 4. In general, yield of barley increased with increasing levels of nitrogen supply (soil and fertilizer nitrogen). Yield response was greatest at low levels of nitrogen supply and decreased as availability of nitrogen increased. In addition, yields of barley attained at a given level of nitrogen supply increased depending on soil/climatic zone in a gradient from south to north. The increase in maximum yields with soil zone was assumed to be an increase in moisture availability.

The development of a climatic data base was similar to that used in Manitoba. Daily records of temperatures and precipitation were attained from the nearest climatological recording station. Maximum and minimum temperatures were used to calculate potential evapotranspiration (Eq. 2). The biometeorological time scale was not used. Although theoretically sound, the time scale added little prediction or calibration accuracy to the model developed in Manitoba. Instead, PE was subtracted from precipitation (P) to indicate a moisture deficit for entry into the model (Eq. 1). Calculations for deficits continued from date of seeding until harvest (assumed to be maturity).

As had been done for Manitoba data, the experimental data was grouped into relative ranges of moisture deficits to determine barley

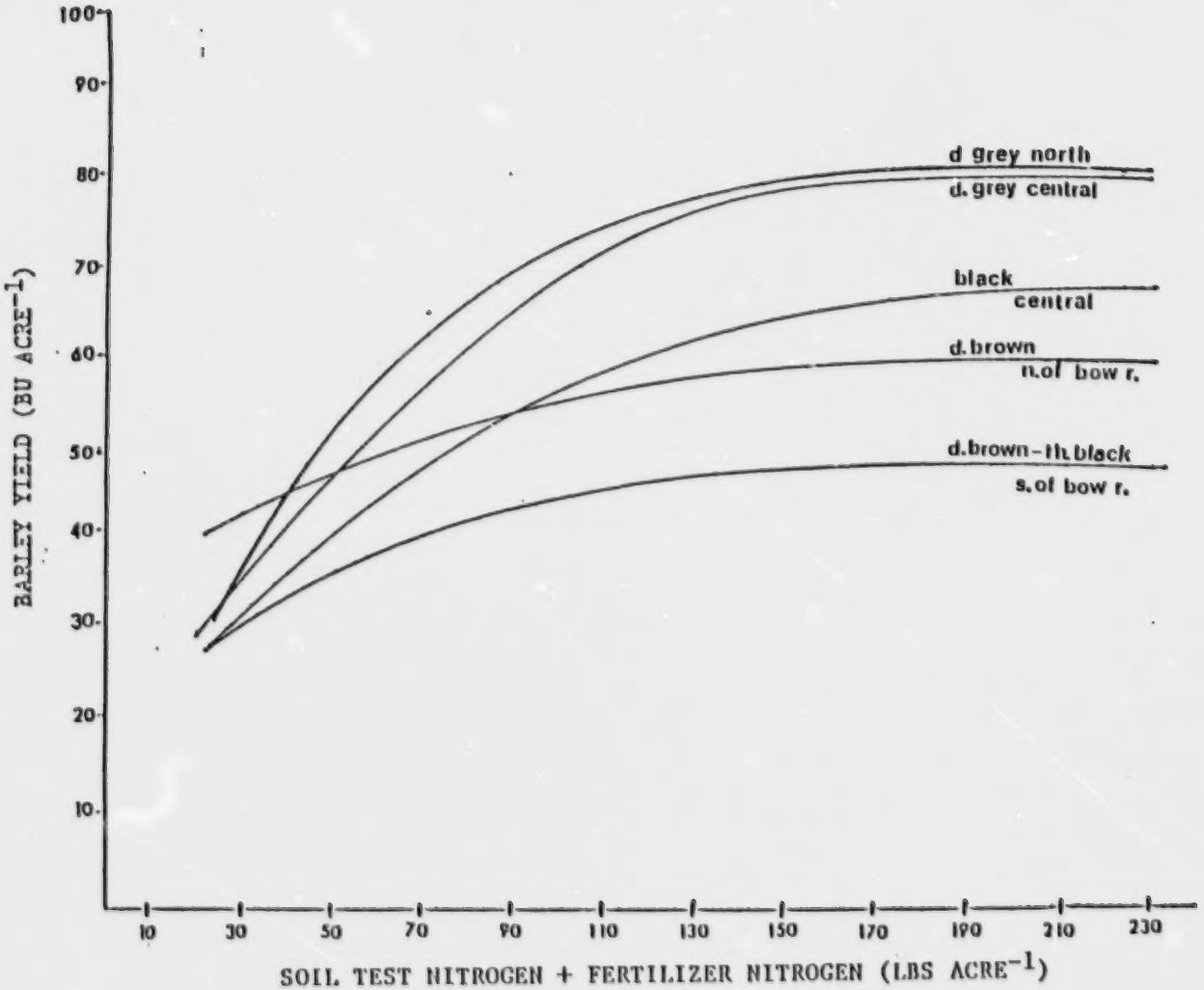

FIGURE 4. EFFECT OF SOIL TEST NITROGEN (0-24") AND ADDED FERTILIZER NITROGEN ON YIELD OF BARLEY AS INFLUENCED BY SOIL (CLIMATIC) ZONE IN ALBERTA (1971-1974)

yield response to nitrogen fertilizer and soil test nitrogen under different levels of moisture availability (Table 4). These data indicate that yield response to nitrogen fertilizer is increased with decreasing moisture deficit and that maximum yield obtained is dependent on Nitrogen supply and moisture availability. Moisture deficits for Alberta's RAYP experimental sites ranged from -700 to 400 mm with 75% of the sites being in the range of -700 to -50 mm. Average moisture deficits of RAYP sites for various soil groups suggest that there is a gradient from south to north in availability of moisture with the exception of the Dark Grey soils in north central Alberta (Table 5). This moisture gradient coincides with increasing barley yields as shown in Figure 4.

Table 4. Effect of Nitrogen Fertilizer, Soil Test Nitrogen (0-24") and Moisture Deficit (P-PE) on Yield (kg ha^{-1}) of Barley on fallow and stubble from 159 site-years in Alberta (1971-1974).

N Added (kg ha^{-1})	Moisture Deficit (mm)					
	-251 to -750		-51 to -250		-50 to 400	
	F	S	F	S	F	S
0	3055.12	1962.46	3309.56	2253.57	3515.27	2369.26
34	3588.85	2446.86	3742.62	2856.02	3672.18	2911.01
67	3690.27	2789.45	3793.57	3219.81	3901.96	3256.34
101	3874.40	2901.54	3831.27	3541.39	3951.00	3407.92
134	3864.26	3068.69	3905.65	3614.92	3995.03	3647.57
168	3284.09	3338.10	3669.38	3739.38	4191.98	3817.29
202	3443.81	3323.83	3727.20	3534.51	4315.27	3894.52
269	3384.97	3307.02	3651.73	3560.47	4242.42	3652.25
Mean Soil Available N (kg ha^{-1})	61	28	77	40	84	44

Table 5. Average Moisture Deficit of RAYP Sites in Various Soil Test Areas.

Soil Test Area	Moisture Deficit mm	Number of Sites
Dk Brown (S of Bow River)	-322.3	7
Dk Brown (N of Bow River)	-196.6	17
Thin Black (S of Bow River)	-246.5	6
Thin Black (S of Bow River)	-145.5	22
Black	-9.0	55
Dk Grey (NE of Edmonton)	-104.2	27
Dk Grey (N & W of Edmonton)	19.5	16
Dk Grey (Peace River)	-218.3	40

A yield response equation incorporating soil test nitrogen, fertilizer nitrogen and moisture deficit was statistically significant ($P < 0.0001$) and accounted for 71% of variation in the experimental data. Yield response curves were generated from this equation and reflect the influence of nitrogen supply and moisture deficit (Figure 5). The lowest curve represents a moisture deficit of -600 mm with yield increases occurring up to 70 kg ha^{-1} nitrogen supply, while the highest curve represents a moisture surplus of 150 mm with yield increases occurring up to 110 kg ha^{-1} nitrogen supply, again suggesting that maximum yield response to nitrogen supply is reflective of moisture availability. The effect of moisture deficit on yield is more substantial at higher deficit and becomes less pronounced when moisture availability is no longer as limiting.

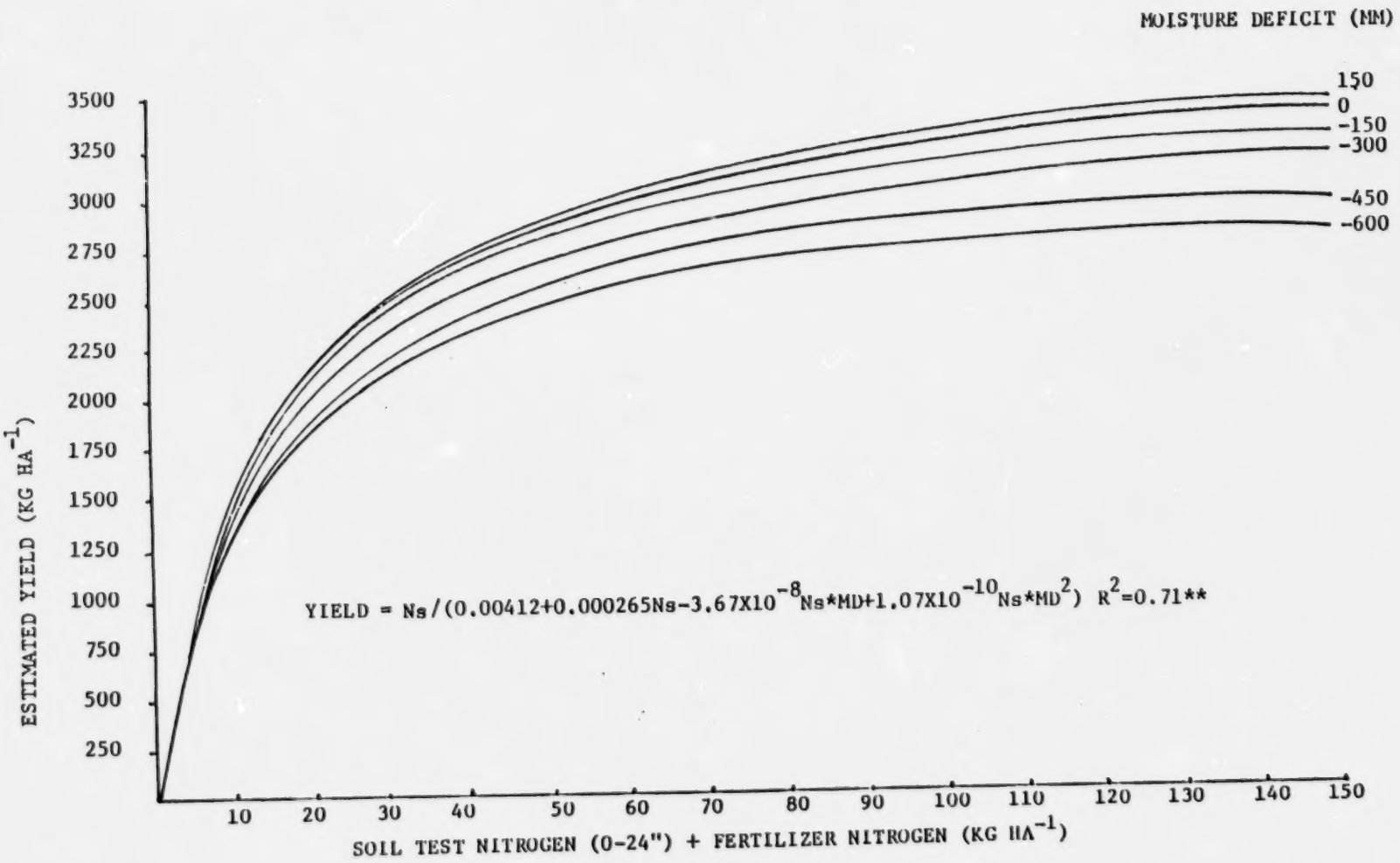

FIGURE 5. EFFECT OF NITROGEN SUPPLY AND MOISTURE DEFICIT ON YIELD OF BARLEY IN ALBERTA.

The amount of yield variation explained by the barley yield equation was 71% for the Alberta experimental data as compared to 80-84% for Manitoba, but the Alberta model represents a wider range of soils and climatic conditions as compared to that of Manitoba. However, even though the variables within the model are not quite the same, the coefficients of nitrogen supply are close in magnitude indicating yield response to nitrogen supply was similar between the two provinces. Higher R^2 values for Manitoba's model along with higher coefficients for yield response to moisture availability suggest that Alberta's moisture availability term was not adequately described or that the model should be expanded to include additional variables to help explain yield response.

Results of this investigation indicate that barley yield response is not only significantly influenced by fertilizer nitrogen and soil test nitrogen but by available moisture as well. Models with weather-based variables would help to explain the year to year and site to site variation in yields improving estimations and fertilizer recommendations. Prediction of crop response is important for making fertilizer and cropping decisions. The work from this project will be incorporated into the fertilizer recommendation process for Alberta.

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MICROCLIMATE OF CLEARCUTS IN WEST-CENTRAL ALBERTA

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ABSTRACT

The effects of clearcuts on the microclimate of forest lands are relatively unknown in Alberta. Any changes resulting from extensive clearings made in the canopy cover of forest vegetation are likely to influence the early growth and survival of planted seedlings in the cut blocks. A study was initiated in 1974 to determine microclimate changes in air and soil temperature in the Hinton leasehold forest where extensive clearcutting had occurred for pulpwood harvesting. Measurements were taken at half-hour intervals over the growing season at increasing distances from the stand edge (15, 46, 91, 137, and 183 m). Analyses are presented for two study areas in Athabasca and McLeod working circles, and comparisons are made for the changes in temperature microclimate of the cut blocks at 10 cm above ground, at ground surface, and at 7.6 and 15.2 cm below ground surface.

INTRODUCTION

Large-scale clearcutting operations are commonly practiced by pulp and paper mills in Alberta as economically acceptable harvesting techniques. Such cuts are normally 16-24 ha in area, but may often extend over 200 ha or more(Johnstone 1984). The microclimatic impact of such large openings in forest canopy is relatively unknown. A study was initiated in 1973 to determine the air and soil temperature variations of clearacuts as influenced by distance from stand edge. Results of the field data collected from two clearcut blocks during 1975 and 1976 are reported in this paper.

METHODS

Study Areas

The two clearcut blocks (Areas 262 and 566) are located in the leasehold (7770 km^2) of Champion Forest Products (Alberta) Ltd. (Fig. 1), which forms part of the boreal forest region. Elevations range from 853 m in the eastern portion of the leased area to 2621 m in the southwestern part, and the mean annual daily temperature varies from 1.0 to 2.9^0 C with a few exceptions (Hillman et. al 1978). Mean annual precipitation ranges between 510 and 560 mm, with July as the wettest and warmest month (Powell and MacIver

Fig. 1. Location of the clearcuts studied in the forest management lease area of Champion Forest Products (Alberta) Ltd., near Hinton, Alberta.

1976).

Area 262 forms part of McLeod Working Circle south of Hinton, whereas Area 566 is in Athabasca Working Circle north of Hinton. Prior to clearcutting, Area 262 supported 90-year old lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.), whereas the dominant vegetation in Area 566 was a 160-year old stand of white spruce (Picea glauca (Moench) Voss) and alpine fir (Abies lasiocarpa (Hook.) Nutt.). The slope and aspect of the study area were: 15-30 % and southwest for area 262, and 5% and northeast for area 566. Areas 566 and 262 were clearcut in 1969 and 1970, respectively. Both areas were drag-scarified prior to replanting with white spruce and lodgepole pine seedlings; area 566 was also blade-scarified with bulldozer, which removed up to 15 cm of mineral soil and created drier microclimatic conditions compared to area 262. Information on soils and other site factors in the two clearcuts is provided by Johnstone (1984).

Microclimate Data

Air and soil temperatures of clearcuts were measured by thermocouples and recorded at half-hour intervals. The measurements were made along two transects at 15, 46, 91, 137, and 183 m from the stand edge. At each point four readings were taken: air

temperature at 10 cm above ground, and soil temperatures at ground surface and at depths of 7.6 and 15.2 cm below the surface. There were thus 48 x 40 = 1920 readings for each day of data collection in each area. Data collection was done through the growing season of 1975 for Area 262 and 1976 for Area 566.

RESULTS AND DISCUSSION

The data presented for Area 262 were collected from 29 June to 31 August, 1975. The data obtained for Area 566 cover the period from 10 June to 2 September 1976. For each half-hour the readings are the average of the two transects.

The temperature trends in the two studied areas showed these patterns:

1. In terms of individual months, the intensity of variation of the four levels of temperature measurements with respect to each other was more in July than in August (Fig. 2, 3). Area 262 showed greater monthly variation among July and August months than Area 566. The differences between ground surface and air temperatures were greater in area 566 than in area 262 (Table 1). These differences were all statistically significant for area 566, and non-significant only in one case in area 262.

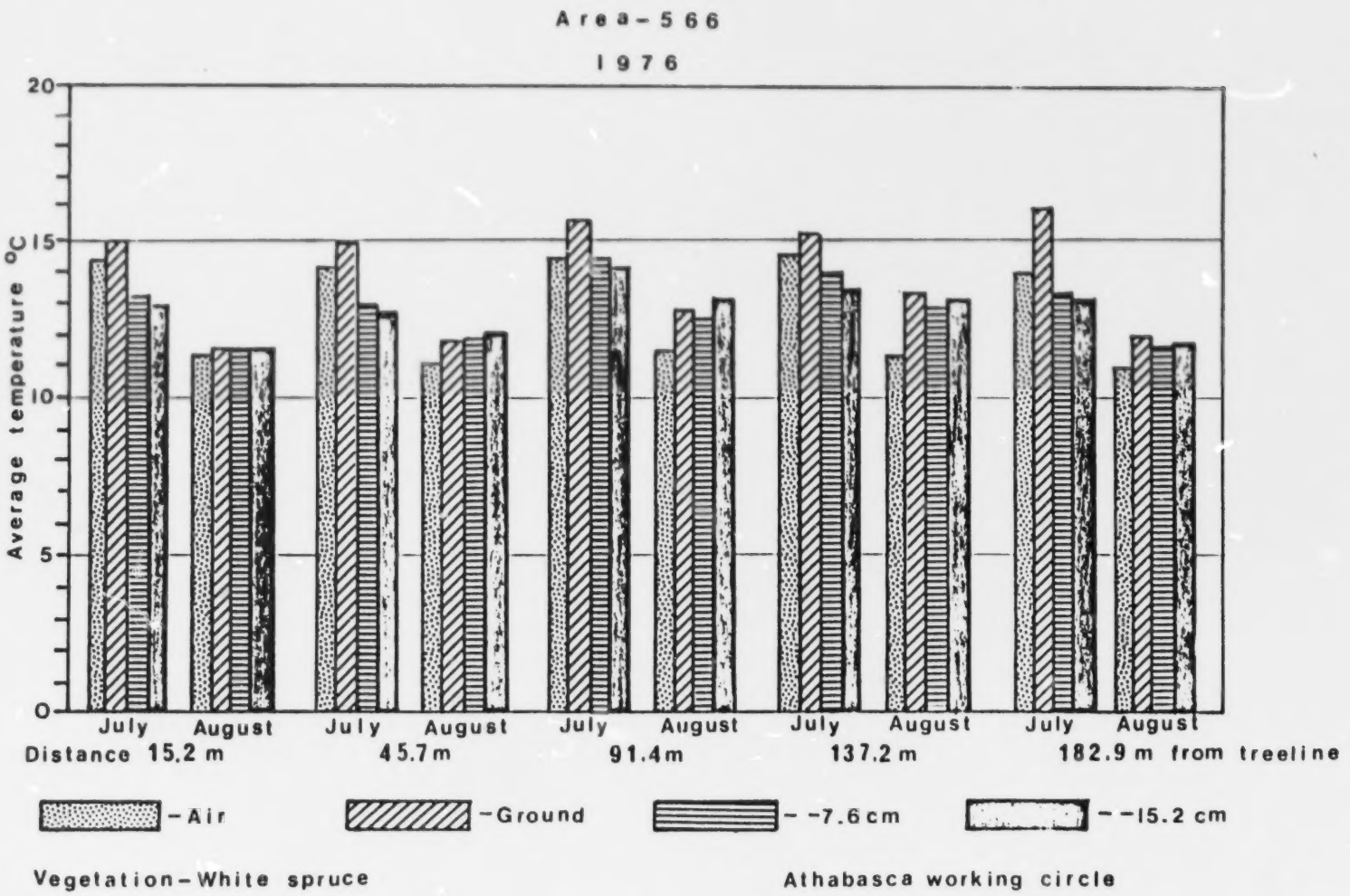

Fig. 2. The mean monthly temperature at increasing distance from the stand edge in clearcut Area 566 for the months of July and August.

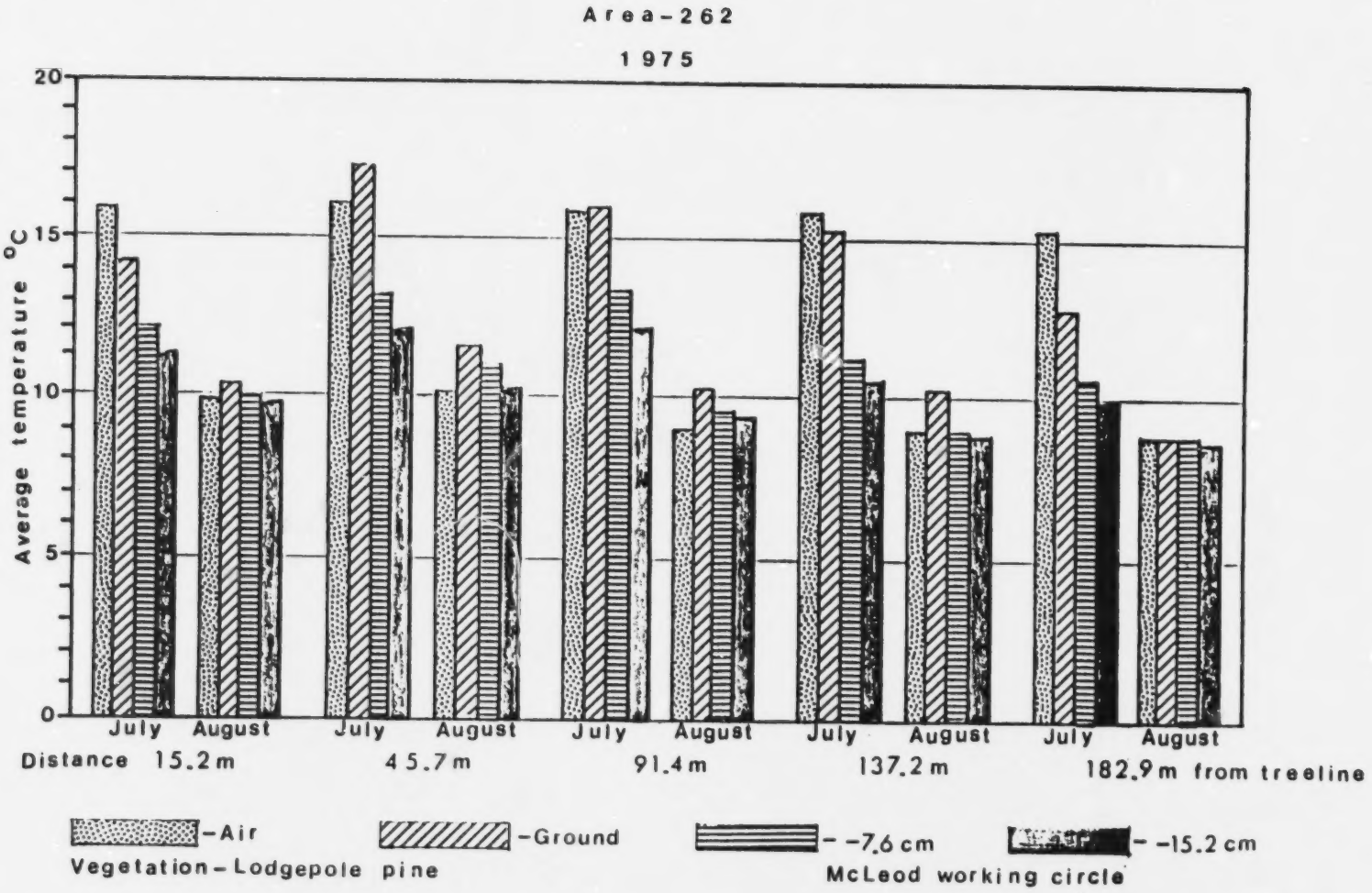

Fig. 3. The mean monthly temperature at increasing distance from the stand edge in clearcut Area 262 for the months of July and August.

Table 1. Mean difference of ground surface temperature (^{0}C) from air temperature in clearcut blocks during July and August, 1975-76.

	Distance (m) from stand edge				
	15	46	91	137	183
Clearcut Area 262 (1975)					
Mean difference	-0.65*	1.28**	0.64**	0.41NS	-1.30**
Standard error of mean	0.26	0.08	0.19	0.26	0.31
Maximum difference	2.5	2.3	2.7	2.5	2.1
Minimum difference	-5.6	-0.2	-3.6	-5.1	- 7.3
Clearcut Area 566 (1976)					
Mean difference	0.59*	0.91**	1.31**	1.26**	1.49**
Standard error of mean	0.23	0.20	0.14	0.21	0.18
Maximum difference	2.5	3.3	2.9	3.9	4.2
Minimum difference	-3.7	-2.2	-1.0	-1.6	-1.4

**Significance at 1 %level. *Significance at 5% level.
NS Not significant at 5% level.

2. The growing season temperatures at the ground surface for the observed time period remained higher than the air mean temperatures throughout the studied distances in Area 566 (Fig. 4). The difference was less persistent in Area 262 (Fig. 5), although majority of the recording stations showed higher mean temperature for the ground surface than air.

3. Soil mean temperatures at depths 7.6 and 15.2 cm were lower than the air mean temperature all through the reported growing period in Area 262, and for distance up to about 70 m from the stand edge in Area 566. However, the soil mean temperatures at these depths in Area 562 exceeded the air mean temperatures at greater distances (approximately 70 - 120 m), and the soil mean temperatures at depth 7.2 cm remained higher than the air mean temperatures at distances of approximately 70 - 183 m from the stand edge.

4. The overall effects of the clearcuts on ground and soil temperatures extended over comparatively greater distance from the stand edge in Area 566 than in Area 262.

The small increases in ground and soil mean temperatures during July and August have to be considered in conjunction with rainfall patterns to determine their combined effect on the growth and survival of seedlings planted in the clearcut areas.

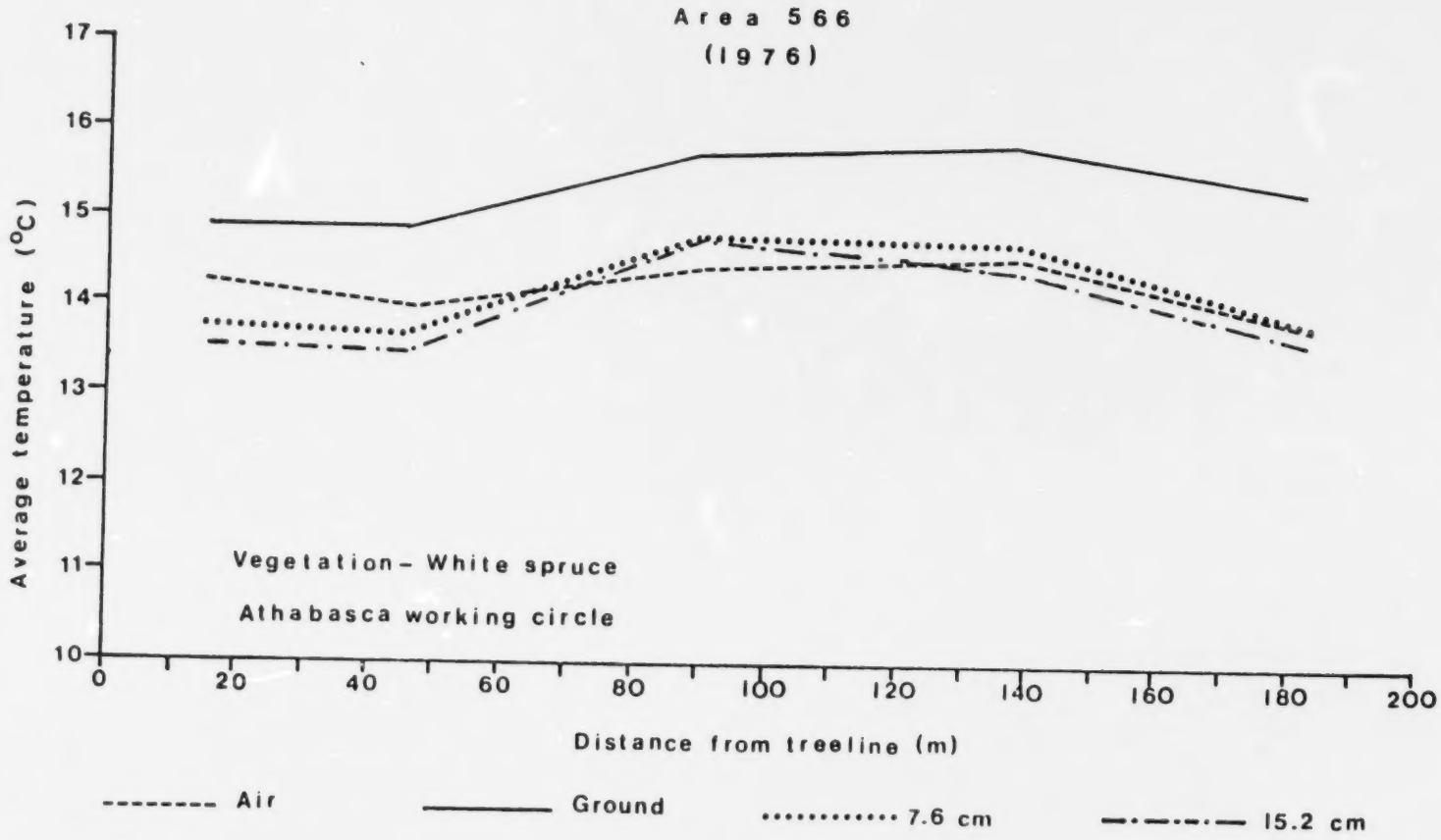

Fig. 4. Comparative daily variability of four levels of temperature measurements in clearcut Area 566 at increasing distance from the stand edge.

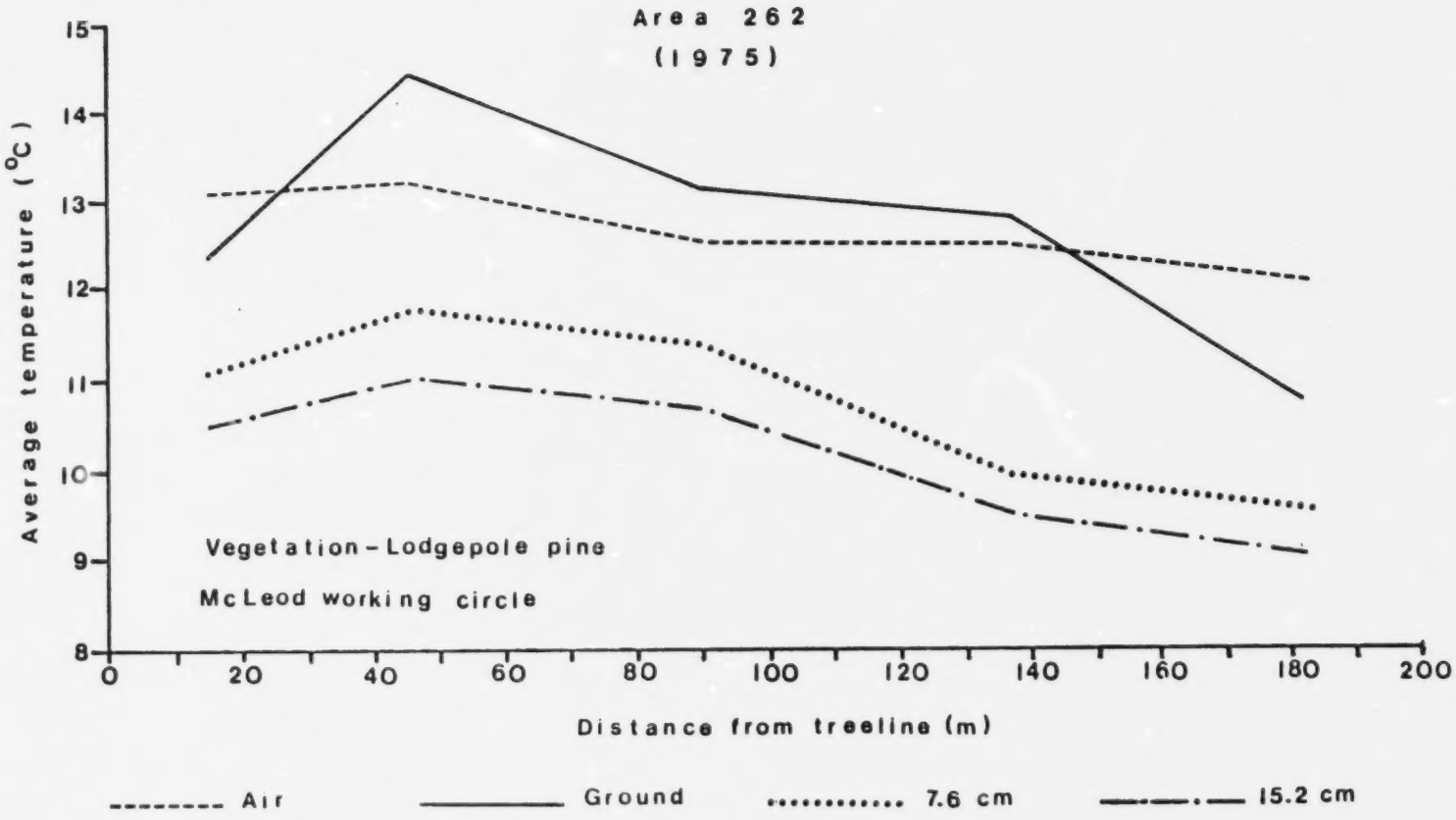

Fig. 5. Comparative daily variability of four levels of temperature measurements in clearcut Area 262 at increasing distance from stand edge.

Whereas the reported increase in mean temperatures could be beneficial in case of adequate moisture supply, the reverse could be true under drought conditions.

ACKNOWLEDGMENTS

The study was started by H.P. Sims and the temperature data were collected under the supervision of J.M. Powell. The author wishes to acknowlege the assistance of D. Campbell in data screening and of N. Schultz in drafting.

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THE APPLICATION AND WORTH OF CLIMATE DATA IN ALBERTA

W.E. Kerr[1] and P. Papirnik[2]

INTRODUCTION

This paper is prepared in response to an invitation from the Saskatchewan Climate Advisory Committee (SCAC) to the Alberta Climate Advisory Committee (ACAC) to participate in their second workshop to be held in Regina on October 10, 1985. Each member agency of the ACAC was requested to contribute to this paper and provide information on the following subjects: agency objectives in relationship to climate, climate data applications, the worth of climate data to each agency, and the type of decisions each agency makes with respect to climate data. Before addressing these subjects, a brief description on the formation and the terms of reference of the ACAC is in order.

In March 1981, the Canadian Council of Resource and Environment Ministers (CCREM) sponsored a seminar on "Climate Change and Variability" in Regina, Saskatchewan. Alberta participated in this seminar and a paper entitled "The Impacts of Climate Change and Variability on Alberta's Resources and Environment" was presented (Leggat, et al 1981). One outcome of this seminar was the decision by the Steering Committee to formulate some recommendations relating to provincial involvement in the Canadian Climate Program. These recommendations were presented to the next meeting of CCREM in September of 1981 and were approved by CCREM in principle. Consensus was reached on a number of actions that followed from the recommendations.

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1 - Secretary, Alberta Climate Advisory Committee

2 - Alberta Environment

The following recommendation is of relevance here.

"3. CCREM should urge provincial governments to take the lead in developing and guiding provincial Climate Advisory Committees whose function would be to help achieve the objectives of the Canadian Climate Program through interaction with all governments and the private sector."

The Alberta Climatological Association (ACA) had attempted to lead the formation of a provincial advisory committee as early as February of 1981. The Association held the founding meeting of the committee in February of 1982, but in view of the CCREM recommendations, decided to withdraw from the leadership of the committee in deference to Alberta Environment. Alberta Environment then assumed the responsibility for the formation of the ACAC to implement the above-noted recommendation. The ACA continues to function as an association of professionals dealing with climatology and promoting the discussion and presentation of ongoing climatological activities in the province.

The following terms of reference for the functioning of the ACAC were developed and approved by the participating agencies, which include Alberta Environment, Alberta Agriculture, Alberta Environmental Centre, Alberta Research Council, Alberta Energy and Natural Resources, Atmospheric Environment Service, Canadian Petroleum Association, an academic representative, and the Alberta Climatological Association.

1. Identify the needs of the various climatic data users in the province and make recommendations concerning ways of meeting these needs.
2. Promote the accessibility and publication of Alberta climate information and data.
3. Identify the climatological concerns for Alberta that require research, monitoring or other action.

The committee normally meets twice a year. Some of the concerns that the ACAC has addressed so far include improvement of climatological data networks, publication of climatological data, development of climate forecasting techniques, and investigation of special areas of interest to its members (Longley, 1977).

ALBERTA AGRICULTURE

Alberta Agriculture is not a major collector of raw climate data, but does utilize data bases available from others such as Alberta Environment and Alberta Energy and Natural Resources. The Department funds the Alberta Research Council studies on weather modification and hail suppression, in which weather and climate data are collected.

The Department does collect data related to individual programs and research projects. These data provide the necessary information to explain research results, and improve the information available to the agricultural community. Applications include land use and irrigation development planning.

Short-term data permit rapid general appraisal of growing conditions across the province which often has a value in short-term planning. Impending problems may be identified, thus permitting the introduction of corrective measures and policies.

Medium-term data permit a general appraisal of how the year has progressed compared to the needs of a specific crop. The use of heat unit accumulation to plan seeding and harvesting activities is an example.

Long-term data are useable for planning purposes and provides the base for development of irrigated land, the assessment of water supplies, the agricultural suitability of Crown land for agriculture, the development of precipitation probability tables, and other farm planning tools designed to reduce risk as much as possible.

No attempt has been made to place a value on climate data. It has sufficient value for the Department to form an agrometeorology advisory committee, to participate in interdepartmental committees on climate, to fund the Agriculture Weather Bulletin, and to support a 24-hour phone-in service to the agricultural community.

Climate data are used in the decision-making process to define drought affected areas and the type of policy required to deal with the problem. The suitability of areas of the province for various agricultural practices is also assessed using climate data.

ALBERTA ENERGY AND NATURAL RESOURCES

Energy and Natural Resources is one of the major climate data generators in Alberta. Branches and divisions generating or using climate data in Energy and Natural Resources (ENR) are: Alberta Forest Service (AFS) - Protection Branch; Resource Evaluation and Planning (REAP); Forest Land Use Branch; Fish and Wildlife; and Public Lands.

Alberta Forest Service (AFS) - Protection Branch operates about 200 Lookout and Ranger Stations during the fire season. Although the main interest is in real-time data, all the data are archived (AES co-operation). Resource Evaluation and Planning operates a number of mesoscale climatological (including dense topoclimate) networks to obtain basic climatological data for long and short-range planning.

Parameters measured by Alberta Forest Service are temperature, humidity, wind, and daily and seasonal precipitation lightning frequency and distribution. Parameters measured by Resource Evaluation and Planning are temperature, precipitation, soil temperature, snow density, snow depth, and hardness.

The future status of current programs within Resource Evaluation and Planning will consist of a redistribution of existing stations and networks in response to planning needs. No major changes are planned to the Sacramento Network. A trend toward full automation of stations

in certain areas of the AFS, fire weather network exists. There is a definite trend toward fewer stations which will be accomplished through a redistribution of existing stations.

Resource Evaluation and Planning and Forest Land Use programs are true climatological programs in every sense of the word. Their objective is to obtain climatological data. In the case of Alberta Forest Service, Protection Branch (i.e., fire weather), the objective is the real-time data but the climate data are a valuable spin-off.

Agency application of climate data include the generation of topoclimatology of the study areas for land use planning, watershed management, culvert design, road design, erosion control, habitat planning, forecasting of wildlife population levels, animal stress evaluation, and comparison of real-time data with climatological normals to evaluate trends in the fire season. This comparison of the real-time data with long-term averages or extremes is especially important to operational agencies such as Forest Protection, and Fish and Wildlife.

ENR must frequently make decisions that depend upon climate data. Examples of these may be found within Alberta Forest Service in fire suppression planning, timing of resource acquisition, deployment of suppression resources, and estimating seasonal expenditures; within Fish and Wildlife in habitat selection for various species and the determination of the numbers of hunting and fishing takes that will maintain specified population levels; within Forest Land Use in culvert and road design, erosion control, and permit restrictions on seismic and drilling activities; and within AFS (Protection) in correlating lightning frequency with fire occurrence and monitoring occurrences of fire-inducing climate conditions across the province to assist in long-term planning.

Climate data are obviously very important to Energy and Natural Resources. The expenditure required to generate, analyse and evaluate the data is sizeable. The decisions based on the data involve tens of millions of dollars.

ALBERTA ENVIRONMENT

Alberta Environment is also one of the major climate data generators in Alberta (Hansen 1982). The two major users of climate data in Environment are the Air Quality Control Branch and the River Forecast Centre. In both areas, climate data are used for the optimum management of the air and water environment in Alberta.

In the Air Quality Control Branch, climate data are required to describe and predict air quality in space and time that results from atmospheric emissions of pollutants. Agency applications of climate data include stack design, monitoring network design, episode prediction and control, land use and transportation planning, control strategy of emissions, assessment of source conditions changes, environmental impact of proposed development scenarios, risk analysis, and emergency response.

Short-term data (one hour to a few weeks) situations:

Emergency response - Climate data are required so that initial risk zones can be determined and future impact can be forecast.

Episode prediction and control - Climate data collected during a pollution episode assist in characterizing the conditions under which the episode occurred and provide data to assist in predicting when these episodes will occur.

Medium-term data (one month to a few years) are used in Environmental Impact Assessments. Since environmental impact from airborne pollutants can have a seasonal variability, climatological data taken over a month or season is needed for air quality model predictions for the desired period. The impact assessment of the Lodgepole, Alberta blowout, which had an emission period of two and one-half months, is an example of an application of medium-term data.

Flood forecasting procedures using simulation models can take advantage of shorter periods of records as long as the climatological station is currently operating and is available in near real-time. The greater the number of stations in a basin, the better the estimate of mean basin precipitation will be. Six hourly totals of precipitation are frequently used in this comparison.

Long-term data collected prior to 1950 are of limited value to the River Forecast Centre. The networks for both hydrological and meteorological data were, for most areas, too sparse to be used for model calibration purposes.

The immediate use of the data is for water management purposes. It is critical that good quality data are available in near real-time so that day-to-day water management decisions can be made. Water management includes flood warning and short and long-term forecasts of expected flow conditions. It is expected that climate data in the future will be used much the same way as it is now, but in more areas of the province.

ALBERTA RESEARCH COUNCIL

The Research Council's objective is to collect and use climate and meteorological data for support and assessment of hail, rain, and snow weather modification research. The principal data collection goal is to obtain precipitation data with high spatial resolution (1 station per 100 km^2). Additional goals are the collection of mesoscale meteorological data and the development and application of remote sensing data acquisition (radar, satellite, aircraft) capabilities.

Data are collected and analysed for physical experiments, storm analysis, and historical climate studies. Analyses include time series, spatial variability of precipitation, joint frequency distributions, Monte Carlo simulations, frequency analysis, and climatological statistics. Applications include evaluation of target and extended area seeding effects, precipitation augmentation potential assessment,

weather/crop-yield modelling, radar-derived estimates of areal precipitation patterns, land reclamation studies, mesoscale meteorology, and agricultural climatology.

Short-term data are generally collected by the Research Council networks. High spatial resolution precipitation data are required for storm case study analysis. Upper air data, used for synoptic analysis of the storm environment, have a high value and are critical to the evaluation of experiments.

Medium and long-term data are used primarily for the evaluation of experiments. Weather modification techniques are assessed by comparing medium-term data sets to long-term climatic trends and patterns. Data used are from both the Alberta Research Council and Atmospheric Environment Service networks.

Radar, upper air, and some Atmospheric Environment Service hourly reports are used for near real-time decisions for physical experiments and operational weather modification activities. This use is high priority. Other radar and meteorological data are used for project evaluations requiring future use of data. Longer-term climate and meteorological data are used to evaluate the efficacy of weather modification techniques.

Data accessibility has improved, particularly in regards to Atmospheric Environment Service hourly and satellite data in the near real-time. This has assisted in field operations. The integration and accessibility of other climate data for longer-term evaluations and assessments is desirable. The continued archiving of other data sets in a computer accessible form would assist in this integration.

ALBERTA ENVIRONMENTAL CENTRE

The Centre's mandate, in general, calls for work in the areas of analytical and diagnostic services, applied research and technical development. That work may be done, without cost to the client, for any

department or agency which requests it. In practice, the main users of AEC services have been the Departments of Environment, Agriculture, Energy and Natural Resources, Workers' Health, Safety and Compensation, the Alberta Research Council, and Health Units throughout Alberta.

This year the Centre has planned to establish a station at the Centre compound to collect meteorological data such as wind speed and direction, temperature, humidity, atmospheric pressure and precipitation. Those data will be used mostly for Alberta Environmental Centre projects.

UNIVERSITIES

The ACAC member represents the universities of Alberta, Calgary and Lethbridge. At each institution, climate data are used to support teaching and research programs.

The University of Alberta operates a well-equipped climate station at Ellerslie, south of Edmonton. The climate station has yielded, over the years, a valuable and continuous set of observations of temperature, precipitation, wind, soil temperatures, radiation, sunshine and pan evaporation. The importance of the climate station as a benchmark (rural undisturbed site) is expected to increase because of the expansion of Greater Edmonton, and the closure of former climatic sites in the region. All data sets recorded at Ellerslie are processed and archived by the Atmospheric Environment Service.

There is also a Weather Satellite Laboratory at the U. of A. which provides research data for staff and students.

The University of Calgary, Department of Geography also maintains a climate station. Data collected support research activities on the wind and temperature structure of the urban environment. Research also focuses on alpine and prairie hydrometeorology, and the micrometeorology of chinooks.

The chinook phenomena is under intense investigation in a co-operative research program in the University of Calgary's Department of Physics. This multi-phased research program includes data from a sodar network, surface measurements of wind and temperature, instrumented aircraft flights and radiosondes. These data will be used to develop a model to describe the physics of the chinook.

The University of Lethbridge collects standard climate data at an automatic weather station. The Department of Geography maintains a large collection of foreign climate data dating back approximately 15 years. This record includes data from Iceland, Japan and Asia.

ENVIRONMENT CANADA

The Atmospheric Environment Service (AES) regions play a key role in the operation of various components of the Canadian Climate Program. The primary responsibility rests with the Scientific Services Division which responds to requests for climate data and information. Significant roles are also carried out by Data Acquisition Division (network operations and standards) and Weather Services Division (both in provision of data and advice to outside users). The domain of responsibility for Western Region's climate services include Alberta, Yukon, and the western Northwest Territories.

The AES Western Region operates a number of networks related to the Atmospheric Environment Service core service programs. A climate data network consisting of 265 stations in Alberta and the Territories is managed by Data Acquisition Division. In addition, climate data reports are also submitted from the 40 stations which comprise the core meteorological network operated jointly by Atmospheric Environment Service and Transport Canada.

All data from the AES managed networks are forwarded to the main climatological data archives in the Downsview Computer Centre in Toronto. Quality control of these data on a monthly basis is a task shared by the regional units (SSD, Data Acquisition) and the Canadian Climate Centre.

Of course, many external agencies also collect data. Some of these networks form components of the AES core network and result in formal agreements on network operation and maintenance. For example, AES has agreements with both Alberta Transportation and Alberta Environment covering a network totalling 20 stations. The Atmospheric Environment Service also undertakes to assist quality control of data from other networks including the 170-station Alberta Forest Service network. When Atmospheric Environment Service and/or an external organization recognize the benefits of the archival of special data sets, arrangements are made to ensure data are placed in acceptable formats for archiving, following the Policy on Non-Standard Data. Little or no quality control of such data is formally undertaken by Atmospheric Environment Service.

Climatic information is provided to a large number of clients in Alberta and the Territories. The range of user groups includes engineering consultants, legal firms and the judiciary, police departments, meteorological consultants, educational institutions, other governments departments, and the general public. The number of requests fielded in Edmonton totals about 5500 per year, increasing at an annual rate of about 8%. In Calgary an additional 5000 requests for climate information are handled. Response to requests in these two centres usually entails a small amount of effort, the primary reference sources being published documents.

Service charges are assessed for most of the requests, by using approved guidelines on cost recovery. This policy is being revised and will result in an increased price structure. Revenues are relatively low at present, totalling $12-$15 000 per year. With the new revenue generation policy, this can be expected to climb to $20-$25 000 per year within the Western Region.

Special studies are conducted primarily to meet internal requirements for preparation of publications. Occasionally, studies and services are contracted in from other government departments (federal and provincial) where the specialized expertise of Atmospheric

Environment Service staff are in demand or access to other Atmospheric Environment Service programs (data or forecast services) are required. These studies are limited to two or three per year and revenue generated is relatively low.

As a service and program coordination agency, the Atmospheric Environment Service is responsible for executing the federal responsibilities under the Canadian Climate Program. These include ensuring the operation of a basic climate data network, to define both long-term climate and its spatial variability on a regional scale. A basic quality control program is operated on the core network and, where required, adjustments are made on network sitings and standards. Policies promulgated by AES Downsview (network standards, DCP policy, observation protocols, data archiving protocols) are implemented by the AES Regional units. Where required, the AES Regions act in a consultative capacity to other agencies having their own or service requirements which frequently compliment the Atmospheric Environment Service-managed programs. Thus, the Atmospheric Environment Service fulfills its role as coordinator of the Canadian Climate Program.

The Atmospheric Environment Service also uses data in the Departmental decision-making process, primarily as related to environmental impact assessment and review. The Service's resources are occasionally used to verify data analyses and the resultant conclusions put forward by industry on environmental impacts of their proposed resource development activities.

Of course, data are also used to assist Atmospheric Environment Service in its own planning and operation. Weather station siting, most of the weather forecast production operation, and briefing services are all guided by appropriate processing of the climate data archives.

CONCLUDING REMARKS

Attributing a value to climate data is difficult, yet it is recognized that its worth to Alberta is far greater than the cost of its collection and storage. The uses of climate data are varied. It supports research projects, aids in crop planning and irrigation, and assists in air quality and water resource management. Ongoing communication between the SCAC and the ACAC is essential for exchange of information on issues of common interest. Mutual co-operation with our neighboring provinces will help our understanding of climate processes and impacts in Western Canada.

ACKNOWLEDGEMENTS

The authors thank the members of the ACAC for their contributions, as well as Dr. H. S. Sandhu, Chairman, ACAC and Mr. B. Janz of Alberta Energy and Natural Resources, for providing guidance in the preparation of this paper.

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PROJECT CATALOGUE OF CLIMATE RESEARCH AND MONITORING ACTIVITIES

PRESENTED TO THE ALBERTA CLIMATOLOGICAL ASSOCIATION WORKSHOP

Approximately one year ago the concept of a project catalogue of climate research and monitoring in Alberta had been tabled at the Alberta Climate Advisory Committee for discussion. The rationale or incentive for a catalogue emerged as a result of several criteria.

1. Several years ago the Research Management Division funded a project to determine and document climate data collection and handling undertaken by Government agencies. The report included the types of data collected and measured and the purpose for collecting the data. The report although useful was limited in that:
   a. it was restricted to government agencies only;
   b. climate research was not documented; and
   c. there was no mechanism to update information on a regular basis.

The report stated that there was a need to communicate information on climate collection programs to both collectors and users of climate data.

2. Various directories and annual reports such as the Natural Resources Information Directory include limited information on climate research and monitoring activities pertinent to specific applications such as land use development or forestry for example.

There is not, however, one publication which summarizes all applied climate, climate research and monitoring programs undertaken or funded by government (federal and provincial), universities, industry, research agencies such as the Alberta Research Council, and the private sector. One possible exception are the proceedings of the Alberta Climatological Association annual workshop wnich includes reports from various agencies on their activities. It was felt that the proceedings would provide the basis for the proposed catalogue. Also the Alberta Climatological Association is probably the biggest link to the climate community in Alberta. Accordingly, the Association was approached with regards to the feasibility of incorporating the catalogue into the proceedings to supplement the existing agency reports. The ACA executive has agreed to assist in this endeavour and incorporate the catalogue into the proceedings.

To supplement the existing agency reports, additional and more detailed information are required. The type of information is detailed below.

CLIMATE RESEARCH AND MONITORING
- TITLE
- DESCRIPTION
- DURATION
- DATA/REPORT AVAILABILITY
- PARTICIPATING AGENCIES
- CONTACTS

An introductory letter and forms requesting this information will be sent to government departments, universities, industry, and research agencies. Your cooperation and assistance in this endeavour will be greatly appreciated.

Depending on the response to and acceptance of the project catalogue, it will be our intent eventually to approach the other western provinces to contribute to it. The detailed information provided will (i) facilitate the exchange of information and coordination of research and monitoring activities, and (ii) provide information invaluable to the indentification and planning of research through the review of research and monitoring activities.

THE LATE-WINTER CLIMATE OF ALBERTA'S OLYMPIC CORRIDOR (CALGARY-KANANASKIS-BANFF)

by

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Abstract

In February 1988 Canada will play host to the world during the XV Winter Olympic Games. Calgary will be the principal venue, while alpine and cross-country events will be staged near Canmore and at Kananaskis. To maximize the development, management, and design of the olympic sites requires detailed information of the corridor's climate.

The olympic corridor is a complex climatological-unit. It has expressions of both cordilleran and prairie climates. These large-scale climates are functions of climate-control mechanisms such as elevation, relief, slope, aspect, and air mass inter-actions.

AGENCY REPORTS

AGRICULTURE CANADA
Alberta Pedology Unit

The soil survey continues to make extensive use of climate data:

a) General characterization of survey areas. These are long term averages of such factors as mean temperatures, moisture and frost free period.

b) Distribution of specific features such as rainfall intensities, snow pack densities, spring melt period, and wind speed. Both temporal and spatial distributions are used for estimates of erosion potential.

c) Combining precipitation and evaporation values with soil moisture characteristics to assess a potential aridity index.

d) Climate is a basic component in soil interpretations for dryland and irrigated agriculture and grazing potentials.

In addition, some soil temperature data are collected on a short term basis to develop a more precise link between soil and atmospheric climate.

W.W. Pettapiece

ALBERTA AGRICULTURE

1. Farm Weather Line

In 1985 Alberta Agriculture, along with the Atmospheric Environment Service (AES), commenced a twenty-four hour weather line service for farmers. The information is updated four times a day by AES on tape machines provided by Alberta Agriculture. Farmers using the lines pay any necessary toll charges. The service started 01 July and ended 31 October at Lethbridge, Calgary, Edmonton and Grande Prairie. Total usage was approximately 55,000 calls with the largest monthly total being 7,000 at Edmonton in October.

The general response to this service was positive by both those providing the service and those receiving it. Some farmers have indicated the desire for more specific local information.

The service is being continued in 1986 at the same level using the same technology.

2. Agrometeorology Advisory Committee

This committee reports to the Alberta Agriculture Advisory Committee and the National Expert Committee on program, extension and research needs for weather and climate factors for agriculture. In 1985, the committee made three recommendations at the provincial level and one at the national level.

The Agroclimate Rating Working Group completed the agroclimate rating system request by the Soil Rating Group. The system is quite different than the one previously used, but the final ratings, although changed, have a similar pattern.

3. Other Activities

a) The wind energy study financed by Farming for the Future funds continues.

b) The Brooks Horticultural Research Center continues to collect climate data at two substation sites and the station itself.

c) Probability of precipitation tables based on thirty years of data were prepared for 78 stations in the agricultural areas.

d) Individuals in several branches continue to collect weather and climate data as it relates to specific studies or interest areas.

ALBERTA ENVIRONMENT
Environmental Protection Services

The meteorological projects completed in 1985 by the Research Management Division concerned either acid deposition effects research or air quality.

The acid deposition research concentrated on forested ecosystems in the northern areas of Alberta. The data bases and methodologies of previous precipitation chemistry studies were evaluated. The FREDIS model used to predict ground level concentrations of SO_2 was validated. The department maintained a close liaison with the Alberta Government/Industry Acid Deposition Research Program.

An air quality/climatology program was developed. Completed projects include the selection of an urban air quality model for Alberta and a study to investigate the feasibility of converting radar imagery data to storm intensity/duration values. Average and instaneous plume behaviour under a variety of low flow rates and meteorological conditions were researched in a project studying stack downwash. A project was initiated to determine the effect of urban air quality on visibility in Calgary.

Staff of the Pollution Control Division, Air Quality Control Branch, participated in a mesoscale monitoring and modelling workshop, in a panel discussion on modelling and monitoring during sour gas well blowouts, and in a joint government industry project to develop a compressor station stack design model. Guidelines were developed for meteorologically controlled emission systems and background ozone concentration data were analyzed. The Alberta Precipitation Quality Monitoring Network was expanded from six to nine stations. The representativeness of sulphate deposition measurements in Calgary was assessed using two additional stations; no significant differences were found. The quantification of sulphate and nitrate in high volume air samples was initiated at the Edmonton and Calgary stations. Work continued on updating user's guides for all models.

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B.L. Magill

ALBERTA ENVIRONMENT
River Forecast Centre

Three new precipitation and temperature stations and one new precipitation station were added to Alberta Environment's real-time meteorological network in 1985. This boosts the number of meteorological stations in the network to 49. The new stations are:

NAME	SENSORS	ELEV.	LATITUDE	LONGITUDE	BASIN
Burns	Precip, temp	1875 m	50°37'34"	114°53'57"	Bow
Streeter	Precip, temp	1370 m	50°06'39"	114°03'02"	Oldman
Medicine - Lodge	Precip, temp	1455 m	49°39'20"	110°19'40"	Lodge Creek
Paddle River Dam	Precip	855 m	53°53'46"	115°04'41"	Paddle

For the first time in 1985, precipitation and temperature data from Alberta Environment's real-time meteorological network has been compiled on tape using the standard AES format. The tape will be forwarded to AES in Downsview for public access.

The weather radar near Penhold was operational for the 1985 runoff season providing information on rainfall amount, intensity and storm movement.

The utility of NOAA (National Oceanographic and Atmospheric Administration) satellite imagery to monitor snowpack depletion in the mountains of Alberta was evaluated for the 1985 runoff season. Snow generated using the ARIES II image analysis system. Snow cover area statistics were generated for 01 May, 12 May, 17 May, 22 May, 18 June, and 03 July 1985. Initial testing confirms that the ARIES II system can provide a suitable and consistent means of estimating snow covered area. The application of NOAA snow cover area estimates to watershed modelling is also being evaluated.

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S. Ferner

ALBERTA FOREST SERVICE
Forest Research Branch

TRI-CREEKS EXPERIMENTAL WATERSHED PROJECT

The Forest Research Branch has been involved with the Tri-Creeks Experimental Watershed Project for the past few years. Precipitation, air temperature, relative humidity, and solar radiation data is collected year round from a dense network of climatic monitoring stations. The study objective will be to: 1) characterize the climate in the Tri-Creeks and surrounding areas 2) assess the transferability of the Tri-Creeks climate to other watershed basins in west-central Alberta, 3) determine storm frequency, intensity and duration statistics and 4) derive water balances from stream runoff and precipitation data.

An additional study involves the determination of snow accumulated in the cutblock as compared to the adjacent forest. Preliminary results indicate a possibility of greater snow accumulations in a large cutblock as compared to the adjacent forest. This has contradicted the general belief that greater snow accumulations appears in the forest.

Allen Nip

USE OF CLIMATIC DATA IN SITE CLASSIFICATION

As part of the biogeoclimatic classification project the Forest Research Branch utilizes available climatic information to identify/delineate homogeneous vegetation zones in Alberta. Climatic parameters utilized by Dr. D.C. MacIvor (1981) in his report "The biogeoclimate of central and northern Alberta" will be required. The above report was funded by the Forest Research Branch; A.F.S. Areas not covered by MacIvor's study (Latitude 49° N - 52° N) will be investigated in the future.

Bela Sivak

ALBERTA HAIL AND CROP INSURANCE CORPORATION

Forage Research Update

A research project to quantify the effect of soil moisture on growth and development of forage crops continued in 1985 at both Brooks (irrigated site) and Lacombe (dryland site). The project is conducted in cooperation with Alberta Horticultural Research Center and Field Crops Branch, Alberta Agriculture.

A second set of plots seeded in 1984 were harvested in 1985 in addition to plots seeded in 1983. In Brooks the field layout for the 1984 seeding was modified for better water control but this resulted in the treatments not completely randomized. In Lacombe the field layout for the 1984 seeding was the same as the 1983 seeding.

At Brooks, alfalfa, brome grass, crested wheat grass and alfalfa-brome mixture were subjected to three water regimes at the pre- and post-bloom periods. Each forage crop was harvested weekly after which a sample was ovendried to determine dry matter yield. At Lacombe, alfalfa, brome grass, crested wheat grass, red clover, alfalfa-brome mixture and alfalfa-crested wheat grass mixture were also harvested weekly at the pre- and post-bloom periods.

Soil moisture was determined every week at both locations. Standard daily weather observations of precipitation, maximum and minimum temperatures, hours of sunshine and pan evaporation were obtained from the climate stations operated by Alberta Horticultural Research Center in Brooks and by Agriculture Canada Research Station in Lacombe.

Analyses of the 1984 and 1985 data are in progress.

Hay and Pasture Crops

Drought (and frost) in Southern and Central Alberta resulted in another heavy payout under the Canada-Alberta Crop Insurance program for hay and pasture crops. Payments amounted to $7.4 million for an average loss of $4.21 for every $1.00 in total premium or $8.42 for every dollar in premiums paid by farmers.

In 1985 the weather-based yield model (used in this Insurance Program) was modified to include extreme temperature and extended-period-of-moisture stress as reducing factors in addition to available soil moisture.

Also the calculated productions of each quarter-township within a district were adjusted according to actual yield of representative hayfields in a district.

Daily rainfall records during the period May 1 to August 31 were provided by 1135 participating farmers. Official records from 170 stations of daily rainfall, temperature and hours of sunshine were obtained monthly from the Atmospheric Environment Service of Canada.

Field activities to support the program in 1985 include: soil moisture observation on over 150 random sites in spring and in summer; preharvest evaluation of more than 150 representative hayfields; yield surveys from more than 550 farms; and actual bale weight measurements of more than 200 selected hayfields.

In 1986 the program will be modified to allow producers to insure their hay crops or their livestock feed requirements. The program will be available in all areas south of and including the M.D. of Clearwater, and the Counties of Wetaskiwin, Camrose, Beaver, Minburn and Vermilion River. Also the program will be known as Livestock Feed Security Program.

Grain Crops

Drought, grasshoppers, frost, poor harvesting weather and early onset of winter have all contributed to another unusually heavy crop losses in 1985. Payments under the Canada-Alberta Crop Insurance program for major crops will exceed $275 million, more than the previous record set in 1984. The two consecutive years of record payments have necessitated withdrawing $114 million from the re-insurance fund of Canada and Alberta and in addition the government will make an interest-free loan of about $75 million to enable the Corporation to cover losses.

I.S Selirio
Bag Service #16
Lacombe, Alberta

ATMOSPHERIC ENVIRONMENT SERVICE

SCIENTIFIC SERVICES DIVISION

The following special reports and climatological studies were undertaken by Scientific Services personnel:

Climate of Edmonton - published
Climate of Calgary - final draft
Station Climate Digest: Calgary - complete
Edmonton - complete
Yellowknife - complete
Inuvik - under preparation
Winter Olympic Corridor Climatology - draft
Climate of Wood Buffalo Park - under preparation
Ice Thickness in NWT - an update of earlier work by B.M. Burns
Hay River Flood Study: May 1985 - completed
September 12, 1985 Rainstorm - under preparation
24-Hour - Summer Rainfall Extremes - under preparation

AES participated in an ad hoc group looking at land use ratings for agriculture.

AES personnel participated in the instrumentation and collection of climatological data for the 1988 Winter Olympic sites at Nakiska, Canmore and Canada Olympic Park and in the overall coordination of the AES Olympic Support Program.

AES personnel also participated in the commissioning of an automatic weather station at King Point, Y.T.

During 1985 there were a number of changes in the climate network. The attached page gives a list of new stations (20), station closures (11) and program damages at existing stations (12).

Scientific Services (Western Region) Reports:

1985-1 Sulphur Deposition in Western Canada during 1982.
1985-2 Atmospheric Environment Service Long Range Transport of Air Pollutant Activities in the Territories
1985-3 Sulphur Deposition Modelling in Western Canada - an update
1985-4 Alberta Rainstorms - Summer 1984
1985-5 Summary of Hydrometeorological Project Reports (AWRP)
1985-6 Breakup Patterns of Landfast Ice Regimes Southern Beaufort Sea
1985-7 September 1985 Beaufort Storm

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1985

New Stations	Latitude	Longitude	Opened
Big Valley	52 02	112 58	85/05
Brule Black Cat	53 21	117 52	85/07
Casino Mtn. (YT)	62 44	138 50	85/05
Cooking Lake	53 26	113 07	85/10
Del Bonita	49 08	112 49	85/05
Five Mile Creek	49 46	113 51	85/06
Grande Cache A	53 55	118 52	85/09
Haines Junction YTG (YT)	60 45	137 30	85/07
Irma West	52 53	111 23	85/07
Keoma	51 15	113 36	85/07
Ketza Mine (YT)	61 32	132 16	85/11
Manning A	56 57	117 38	85/09
Midway Project (BC)	59 56	130 20	85/10
Paulatuk A (NWT)	69 21	124 05	85/06
St. Vincent SE	54 07	111 13	85/07
Suffield South	50 04	111 10	85/05
Sundre Garrington	51 58	114 27	85/07
Swan Hills A	54 40	115 25	85/09
Wetaskiwin South	52 58	113 23	85/08
Wolf Creek (YT)	60 30	134 57	85/06

Stations Closed	Latitude	Longitude	Closed
Big Coulee	49 45	113 48	85/06
Bowden	51 59	114 01	85/06
Bragg Creek West	50 58	114 37	85/06
Chestermere Lake South	51 02	113 47	85/06
Forty Mile (YT)	64 24	140 36	85/01
Haines Junction (YT)	60 45	137 35	85/05
Hanna	51 35	111 51	85/02
Hughenden	52 31	110 58	85/08
Little Doctor Lake (NWT)	61 53	123 14	85/05
Redcliff	50 04	110 46	85/01
Whiskey Gap	49 01	112 57	85/05

Program Changes	Latitude	Longitude	Program Change	Date
Alliance South	52 25	111 47	P to TP	85/06
Camrose 2	52 57	112 48	P to TP	85/07
Contracosta Lake	51 46	111 33	P to TP	85/08
Craigmyle	51 46	112 17	P to TP	85/05
Donnelly	55 44	117 06	P to TP	85/05
Ghost Pine Creek	51 39	113 05	P to TP	85/06
Gibbons	53 49	113 10	P to TP	85/06
Hackett	52 09	112 28	P to TP	85/05
New Brigden East	51 41	110 16	P to TP	85/06
Oakland Lake	51 23	111 57	P to TP	85/06
Sundre	51 45	114 47	P to TP	85/05
Wetaskiwin South	52 58	113 23	P to TP	85/09

CANADIAN FORESTRY SERVICE
Northern Forestry Centre

Climate-related research activities at the Northern Forestry Centre were mainly in these categories: climate of boreal forest and wetlands, forest hydrology, and fire-related climatic research.

Climate of the boreal forest

The boreal forest is a major tract of forest land with considerable importance for Canada. The influence of climate on the growth of trees in general, and of microcliamte on regeneration and establishment of seedlings in harvested areas in particular, provided the rationale for continued analysis of climatic data during the year. The data used were supplied by the Canadian Climate Centre and the data collected by the Canadian Forestry Service near Hinton, Alberta. Based on climatic records of 101 stations in the boreal forest, the mean annual temperature and precipitation for the boreal forest subregions were computed as: forest-grassland transition 1.5 °C, 444.8 mm; predominantly forest -0.6 C, 439.2 mm; and forest-tundra transition -7.1 C, 303.0 mm, respectively. Highly significant (P 0.01) differences were detected in the mean monthly temperature among the subregions for each month, and similar differences were found in precipitation for most months. Long-term data showed slightly increasing temperature and precipitation trends within the predominantly forest subregion. The results are being presented as a journal paper accepted for publication by 'Climatic Change'.

Temperature data collected on two clearcuts located in the leasehold of St. Regis (Alberta) Ltd. near Hinton were analyzed for comparing microclimate of the cutblocks at increasing distances from the stand edge. The analyses showed interesting patterns in ground surface and soil temperatures; these are being reported separately in a paper for this workshop.

Wetlands

Wetlands are widespread in the prairie provinces and other parts of Canada. Peatlands create their own environment as an ecosystem of which climate is an important component. The study of peatland dynamics has been in progress at the Northern Forestry Centre for the Boreal Wetland Regions of Alberta, Saskatchewan, and Manitoba. An ecoclimatic map of Canada was finalized and the manuscript of a report prepared. Steve Zoltai prepared three chapters for the book "Wetlands of Canada", and contributed to a chpater on wetlands of the arctic regions of Canada; these manuscripts are presently in the review stage. A paper by him has been accepted for inclusion in "International Perspectives of Periglacial Research" being publsihed by John Wiley & Sons Ltd. Steve Zoltai also acted as a member of the editorial group for "Wetlands of Canada".

The main objective of the wetland drainage project under the joint Wetland Drainage and Improvement Program of Canadian Forestry Service and Alberta Forest Service is to develop optimal silvicultural regimes for increasing the growth of commercial tree species on drained wetlands. Three experimental areas (Goose River, McLennan, and Wolf Creek) were established during 1985 for the study; about half of each area is scheduled for drainage, the remainder will serve as control. A weather station consisting of a recording precipitation gauge and a recording hygrothermograph were installed on each area, and nearly 400 samples collected for physical and chemical analysis. Over 100 hydraulic conductivity measurements were made, mostly at 0.6 m depth. Final plans for the drainage ditch networks have been completed and the field layout of these networks is currently in progress.

Forest hydrology and microclimate

The microclimate of 1, 3 and 5 tree-height diameter forest clearings was monitored during the past winter. Fourteen sites were instrumented with wind, net radiation (all wave), relative humidity, and air and snow temperature sensors. Snow evaporation, as determined by weighing small pans, was generally less than 0.5 mm/day. Preliminary results indicated that evaporation from snow was small, as long was wind speed near the ground was low. Most of the incoming energy caused melt - even during January.

Weather and snow data for Marmot Experimental Watershed (Mount Allen) were in less demand than last year. The data from four permanent stations operated by the Canadian Forestry Service are now available in IBM-PC format suitable for direct entry into Lotus 1-2-3. These are also available on tape or via modem from the Northern Forestry Centre's Vax system.

Several versions of the WRENSS procedure to predict annual water yield from harvested or natural forested areas are now available. One such version is on line on the University of Alberta computer ($RUN VSAS:WRENSS); two other versions are available for the IBM-PC in either compiled FORTRAN or as a LOTUS 1-2-3 spread sheet. The procedure uses a set of climatically similar zones, forest cover type and local precipitation to provide estimates of annual water yields that are generally within 10% of the actual. The IBM versions are available from Pierre Bernier (Tel: 435-7358), as is the information on the most recent computerized version at the University of Alberta.

Forest fires and climatology

Technical and scientific seminars on fire-weather related topics were held in Winnipeg and Edmonton, and the proceedings for these were made available.

Field work continued on the joint Canadian Forestry Service/Alberta Forest Service experimental burning project in northwestern Alberta. Preburn inventory of fuels was completed. Six successful experimental fires were conducted and documented under low to moderate fire danger conditions. Head fire spread rates up to 30 m/min were observed.

A set of dew-point temperature tables were prepared for fire-weather stations with ventilated thermometers. These are analogous in format to the present relative humidity tables in the Canadian Forest Fire Weather Index (FWI) Systems Tables (i.e., dry- and wet-bulb temperatures in 0.5 C increments). A comprehensive inter-active computer program, designed to calculate the FWI System components and archive 1200 h LST fire weather observations, has been developed.

Two members of the Northern Forestry Centre participated in the review of Canadian committee on the glossary of forest fire management terms.

Publications

Alexander, M.E. 1985. Proceedings of the second Central Region Fire Weather Committee technical and scientific seminar (April 17, Winnipeg, Man.). Govt. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alta. STudy NOR-5-05 (NOR-5-191) File Rep. No. 11.

Alexander, M.E. 1986. Bibliography on the Canadian Forest Fire Danger Rating System: 1969-1985. Govt. Can., Can. For. Serv., North. For. Cent., Edmonton, Alta. Study NOR-5-05 (NOR-5-191) File Rep. No. 12.

Alexander, N.E. 1986. Proceedings of the third Western Region Fire Weather Committee technical and scientific seminar (Feb. 4, Edmonton, Alta.). Govt. Can., Can. For. Serv., North. For. Cent., Edmonton, Alta. Study NOR-5-05 (NOR-5-191) File Rep. No. 14.

Alexander, M.E., and G.P. Delisle. 1986. References bibliographiques sur la Methode Canadienne d'Evaluation des Dangers d'Incedie de Foret: 1969-1985. Govt. Can., Can. Fort. Serv., Nor. For. Cent., Edmonton, Alta. Study NOR-5-05 (NOR-5-191) File Rep. No. 12F.

Canadian Committee on Forest Fire Management. 1986. Glossary of forest fire management terms. Fourth edition. Natl. Counc. Can., Ottawa, Ont. Publ. NRCC No. 15520 (in press).

Harvey, D.A., M.E. Alexander, and B. Janz. 1986. A comparison of fire-weather severity in northern Alberta during the 1980 and 1981 fire seasons. For. Chron. 62: (in press).

Singh, T. 1986. Microclimate of clearcuts in west-central Alberta. Proceedings of the 10th Annual Workshop, Alberta Climatological Association, Edmonton, Alta.

Singh, T., and J.M. Powell. 1986. Climatic variation and trends in the boreal forest region of western Canada. Climatic Change (in press).

Teja Singh

ENERGY AND NATURAL RESOURCES
Resource Evaluation and Planning

Two mesoclimatic networks in the Peace have been closed while a third stretching from Peace River to Red Earth has been expanded. Conversion to more automated electronic data loggers is progressing slowly.

A draft report on the mapping of agroclimate for one of the Peace River networks has been completed and is in the process of finalization.

The climate unit contributed actively in the province wide analysis and mapping of climate for use in agricultural land assessment. The new series of maps at a scale of 1: 2 000 000 have been released for review in a revised Agricultural Rating System developed by ENR, Alberta Agriculture and Alberta Soil Survey.

A number of consultative services continue to be conducted on behalf of the department. These included contribution to ecological Land Classification, Biogeoclimatic zonation and climatic summaries of various kinds.

Serge Dupuis

ENVIRONMENT CANADA
Water Resources Branch
Inland Waters Directorate

The Water Resources Branch is comprised of two divisions: the Water Survey of Canada Division (WSC) and the Hydrology Division. The WSC is the agency responsible for collecting, archiving and distributing water quantity data from a nationwide network of more than 3 000 gauging sites. Primarily, this data consists of river and stream discharges, but also includes flow velocities, widths, depths, water level fluctuation in rivers and lakes, sediment transport, and less consistently more general data such as water temperature and ice thickness. The Hydrology Division conducts analytical and interpretive studies designed to complement the basic data collection activities of the WSC.

Water Survey of Canada data is available free upon request, and may be obtained by contacting the regional offices in Vancouver, Calgary, Regina, Winnipeg, Guelph, Longueuil, Dartmouth or Yellowknife.

Greg MacCullock

Prairie Farm Rehabilitation Agency (PFRA)

PFRA CLIMATLE RELATED ACTIVITIES

The Water Supply Conditions Report for the Prairie Provinces is published three times annually, generally in early May, early July and early November. This is a relatively comprehensive real time report on the availability of water for on-farm, domestic, urban, industrial and other agricultural use. The report includes an evaluation of soil moisture, pasture conditions and a general agricultural summary. A section on wind erosion potential has recently been included. The information provided by numerous provincial, federal and private agencies is gratefully acknowledged.

PFRA has in cooperation with Alberta Agriculture, Saskatchewan Agriculture and the Land Resource Research Institute, initiated a pilot project to monitor the potential for wind erosion. The objective of this project is to increase awareness of the extent and magnitude of the problem. This is intended to encourage the incorporation or conservation practices in farm management systems and to assist policy makers in their management decisions.

The experimental Long Range Forecasts produced by the Canadian Climate Centre have been evaluated since March 1985, for potential application to drought monitoring activities. This process is on-going.

A paper entitled "An Economic Evaluation of Impacts of the 1984-85 Prairie Drought," has been completed for presentation during the CHS '86 Conference at Regina. This paper estimates the loss of Gross Domestic Product for the Prairies as it relates to cereal and forage yield reductions.

A report was published in the fall of 1985 entitled the Alberta Water Sourcing Study, Phase 1. The study provides an inventory of existing drought-proof water sources, delineates areas deficient in water for dugout pumping and documents deficiencies in on-farm or community water supplies, which became apparent during the 1984 drought. A similar study is being carried out in Saskatchewan and Manitoba and is scheduled for completion in the summer of 1986. Phase 2 of the Alberta Study will evaluate water development potential, which will alleviate water shortages in the water deficient areas.

A meeting of crop and climate monitoring specialists working in western Canada was held at Regina, January 13-14, 1986. The informal agenda promoted an active exchange of ideas related to monitoring programs and methodologies used in agroclimatic analyses. As suggested by the participants another meeting will be held in the future and we will ensure that the meeting will not coincide with the Alberta Agrometeorological Committee meeting, to facilitate their welcome participation.

There has been an increased interest in field shelterbelts in Western Canada during the past five years. The Tree Nursery at Indian Head has been conducting a series of studies to provide up to date information to farmers

and other prairie tree planters on the proper spacing, species and management practices for field shelterbelts. Also, more information is being collected on the benefits of shelterbelts. At the present time various projects are underway to determine the effects of shelterbelts on microclimate and crop yields. General titles of these projects are as follows:

1. Effects of field shelterbelts on soil erosion by wind.

2. Wind profiles for different shelterbelt species - summer and winter.

3. Effects of shelterbelts on microclimate and subsequently on crop yields.

4. Effects of shelterbelts on soil moisture.

5. Effects of shelterbelt spacing on snow trapment.

Results of the above studies are reported in the Tree Nursery Annual Report, Prairie Farm Rehabilitation Administration.

A study on the "Shelterbelt Benefit to Home Heating Cost," has recently been completed and is being submitted for publication. Study results indicated a sizeable reduction in winter seasonal heating costs through the use of good quality shelterbelts. Study results can be used to predict reasonable savings for various shelter types for an area for which climate normals are known and for dwelling types of similar character to those used in the study.

A national lecture tour has been made by G.H. MacKay an officer of PFRA. The lecture for the Associate Committee on Hydrology was entitled, "The Hydrology of Drought."

UNIVERSITY OF ALBERTA
Meteorology Division and
Institute of Earth and Planetary Physics

EVALUATION OF GROUND GENERATOR CLOUD SEEDING IN SOUTHERN ALBERTA

In recent years claims have been made to the effect that cloud seeding by the emission of siver iodide from ground-based generators in southwestern Alberta during the summers of 1977 and 1980-1983 have resulted in rainfall increases of 30 to 40 percent. Rainfall data in this region were re-examined, using estimates of target area rainfall in the absence of cloud seeding based on (a) pre- and post-seeding target-to-control rainfall ratios, (b) predictor stations selected by correlation analyses from 32 long-term control area rainfall stations, and (c) interpolation by objective spatial analysis from a large number of control area rainfall stations surrounding the target. No evidence was found of a significant change in the target-area rainfall. The correlation method (which utilized 57 years of rainfall data) should have been capable of detecting a 12 percent change in target rainfall with 95 percent confidence.

N. Aktary and K.D. Hage

ATMOSPHERIC PHYSICS

Work is continuing on the simulation of atmospheric and marine icing, both experimentally and by computer modelling. A new marine-icing wind tunnel is under construction, the only such facility in Canada. Twelve staff and graduate students in Meteorology and Mechanical Engineering are currently examining various aspects of ice accretion, ranging from droplet generation, transport and measurement, through thermodynamics and heat transfer to the physical properties of accreted ice.

G. Strong has completed a Ph.D thesis based on the analysis of the severe weather of May 20-21 in Oklahoma and Texas. His results demonstrate the interaction between the synoptic and meso scales of atmospheric motion.

E. Chan is testing the capability of the AES General Circulation Model for long-range forecasting. In particular, he is examining the sensitivity of the model to the sea-surface temperature forcing associated with the most recent El Nino event.

E. Lozowski, K. Szilder, G. STrong, K. Finstad, A. Nowak, R. Blackmore, W-W. Jiang, Y. Zhuang, E. Chan

ATMOSPHERIC BOUNDARY-LAYER STUDIES

A two-dimensional finite-difference numerical model of airflow and pollutant dispersion in a small valley was completed. The model simulated the vertical development of a supercritical Richardson Number layer of air containing nocturnal downslope drainage, by decoupling such a layer from the prevailing winds above. The predicted wind and temperature distributions within a few metres of the surface agreed well with observations taken in the North Saskatchean River Valley in Edmonton.

R.K. Wong and K.D. Hage

MESOSCALE AND SATELLITE METEOROLOGY

F. Safwat has completed an extensive study of cloud configurations accompanying cold lows and upper-level cyclogenesis. Making use of satellite images, he has identified six stages of upper cyclone development, from the initial cold trough at the 500-mb level, to the splitting of the Westerlies and the pinching-off stage, the cutting-off stage, normally preceding and leading to the mature storm stage, and ending with the decay stage. Safwat has also revised the current synoptic cloud classification, and extended it by including the post-frontal band, a cloud formation not previously recognized as a distinct and separate entity.

C. Sackiw has completed a study on the cohesiveness of upper-air soundings in space and time. Differences in pressure, temperature and wind are examined from data sets obtained from serial releases of radiosonde balloons. The results of this study will help in the design of an upper-air network capable of detecting and tracking atmospheric systems on a scale of a few kilometres.

Knowledge of the relationship between surface weather patterns and specific meteorological parameters is important in the production of fire-weather forecasts. E. Reinelt is preparing a synoptic climatology associating weather patterns with upper-air parameters relevant to the incidence and control of forest fires. Thus low-level jet winds may lead to "blow-ups" and the rapid spread of forest fires. A catalogue of vertical wind and temperature profiles is being compiled for specific sites within the boreal forests of Northwestern Canada.

C. Sackiw, F. Safwat, E.R. Reinelt

ENVIRONMENTAL STUDIES AND RADAR METEOROLOGY

Studies of man-made snow, fog and cloud on very cold days in the petrochemical distrist of Edmonton continue. F. Hopper has examined the increasing frequency of ice fog in Edmonton, enhanced by the addition of substantial amounts of water vapour and particulates by motor vehicles and the burning of large volumes of natural gas in winter.

F. Hopper is also investigating the chemical composition of Arctic aerosols, using data collected by the Atmospheric Environment Service. observations of sky turbidity during the past several years suggest that the atmosphere of the High Arctic is subject to high aerosol loads in winter, thought to be due to pollution likely to originate in Eurasia.

K. Al-Jumily and D. Yiu are continuing the analysis of radar and airborne cloud physics data obtained from the Alberta Research Council Hail Project.

R. Charlton, F. Hopper, K. Al-Jumily, D. Yiu

ALBERTA CLIMATOLOGICAL ASSOCIATION ANNUAL MEETING
FEBRUARY 20, 1986
B-95 Tory Building, University of Alberta

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ACA Interest Survey

Topic	Overall		Choice by topic	Choice Overall
Impacts of climate change on agriculture, settlements, construction, transport, etc.	66%	1	63%	42%
		2	25%	17%
		3	13%	8%
Planning for climate change	54%	1	0%	0%
		2	38%	21%
		3	62%	33%
The climate of Alberta, general, agricultural, recreation, etc.	46%	1	36%	17%
		2	27%	13%
		3	36%	17%
Overview of climate classification system (models), their strengths and weaknesses.	38%	1	33%	13%
		2	33%	13%
		3	33%	13%
Micrometeorology, general, agriculture, recreation, etc.	33%	1	38%	13%
		2	25%	8%
		3	38%	13%
History of climatological measurement, old days to the present.	8%	1	0%	0%
		2	100%	8%
		3	0%	0%

Format	Overall		Choice by Format	Choice Overall
Conference	79%	1	42%	33%
		2	21%	17%
		3	37%	29%
Workshop	75%	1	44%	33%
		2	44%	33%
		3	11%	8%
Panel	63%	1	33%	21%
		2	33%	21%
		3	33%	21%
Tutorial	25%	1	17%	4%
		2	50%	13%
		3	33%	8%

24 Surveys received.

PROJECT INVENTORY CATALOGUE

The first project catalogue of climate research and monitoring activities in Alberta has been completed.

To obtain the required information, a project inventory form was sent to over 100 contacts who had previously indicated an interest or involvement in climatology. Over 40 current projects were identified from the responses that were received.

The projects have been categorized and separated into monitoring or research activities. Within each area, projects were further classified according to subjects. These subject areas included descriptive climatology for projects describing the climate of an area or region, hydrological research, soil, agriculture/wildlife, forestry, energy, fire, and air quality. These topics attest to the variety of climatological work ongoing in the province.

It is anticipated that this will become an annual publication and will include even more projects next year. Thank you for your co-operation in submitting details on the individual projects.

1. RESEARCH

1.1 General

Feasibility of a Climate Service Centre

The feasibility of establishing a climate service centre was investigated. Detailed questionnaires and follow-up interviews were used to obtain information on what data are required, how it is acquired, and how it is used or analysed. The study identified potential users of climate data.

This project was completed for Alberta Environment by KelResearch Corporation. The summary report will be published by early 1987 and will be available from the Research Management Division, Alberta Environment.

Contact: B.L. Magill
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(403) 422-2070

1.2 DESCRIPTIVE CLIMATOLOGY

Climate of the Olympic Corridor

Using available climate data from the Atmospheric Environment Service and Alberta Forestry Service, a climate study of the Calgary-Kananaskis-Banff corridor has been produced in preparation for the 1988 Winter Olympics. The report, to be completed in early 1987, will be used for planning purposes.

The study was completed by Environmental Climate Services under contract to Atmospheric Environment Service.

Contact: Manfred Drews
Atmospheric Environment Service
2nd Floor, Twin Atria Building
4999 - 98 Avenue
Edmonton, Alberta T6B 2X3
(403) 420-3143

Climate of Wood Buffalo National Park

Available climatological data from the Atmospheric Environment Service were used to produce a climate study of Wood Buffalo National Park. The report, which was completed in March 1986 and forwarded to Environment Canada-Parks, will be used in developing a resource description and analysis for the park.

The work was completed by Environmental Climate Services under contract to Atmospheric Environment and Environment Canada-Parks.

Contact: Neil Parker
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(403) 420-3143

Biometeorology of Winter Weather in Southern Alberta

A survey of approximately 2500 residents in Lethbridge, nearby towns and rural areas was undertaken. Responses to several physiological and psychological questions regarding human well-being were solicited. These data are being analyzed in relation to 48-hour weather types, meteorological conditions and other variables. A summary report is planned for 1987.

Contact: Roy J. Fletcher
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Lethbridge, Alberta T1K 3M4
(403) 329-2535

Atmospheric Ionization During Winter in Southern Alberta

Outdoor and indoor, positive and negative ion counting during various weather types, especially at 8:00 a.m. and 8:00 p.m., was undertaken during the period 1983 to 1985 in a Lethbridge suburb. Measurements were taken from October to April, inclusive. A report is planned for 1987.

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Boundary Layer/Diffusion Climatology for Central Alberta

A single station, located southwest of Edmonton, measures wind, temperature stratification, and turbulence as inputs to atmospheric dispersion models. The installation includes a balloon-borne temperature sonde, a Doppler Acoustic Radar, a 20-m instrumented tower and equipment for measuring radiation (global, reflected and net), turbulent heat flux, pressure and ozone concentrations.

Data records start in 1978 and continue to the present. Different parameters have different commencement data in 1979, 1980 and 1981. Monthly and annual data summaries are available.

Contact: Randy Angle/Steve Sakiyama
Air Quality Control Branch
Pollution Control Division
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Supplementary Emission Control

Research is ongoing to develop a method of forecasting ground level concentrations of sulphur dioxide. The feasibility of controlling SO_2 emissions during adverse meteorological conditions has been studied at Tar Island, Alberta since 1981. An acoustic radar data base is used to describe dispersion conditions which are correlated to regional meteorological conditions.

Contact: John Letkeman
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P.O. Box 4001
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(403) 743-6687

Climatology and Hydrometeorology of the Tri-Creeks Experimental Watershed

Research has been ongoing in the Tri-Creeks Experimental Watershed near Cadomin, Alberta since 1967. This project has several objectives: (1) to compare pre- and post-harvest climate; (2) to document the climatology and hydrometeorology of the area; (3) to determine whether the Tri-Creeks climate can be transferred to west central east slopes basins; and (4) to determine the hydrometeorology statistics for the Tri-Creeks study area. All available climate data of the Tri-Creeks area were analyzed. The report will be completed by November 1986.

Work was undertaken by Environmental Climate Services under contract to Alberta Forestry, Lands and Wildlife.

Contact: Allen Nip
Forest Research Branch
216 McLeod Avenue
Spruce Grove, Alberta
T0E 2C0
(403) 962-8700

1.3 HYDROLOGICAL RESEARCH

Hydrological Effects of Land Use Changes

The objective of the study is to provide a field test and evaluation of hydrologic effects from different land use practices using F.I. Morton's procedures for calculation of evaporation losses in the water balance equation. The study sites (3), in the Oldman and South Saskatchewan river basins east of Lethbridge, represent native grassland, irrigated cereal crop and dry land crop land use. The study extends from May 1986 to May 1987. Participating agencies include National Hydrological Research Institute, Water Survey of Canada, Lethbridge Research Station, and Alberta Environment.

Contact: Walter Nicholaichuk
National Hydrological Research Institute
Room 1750, Sedco Centre
15 Innovation Blvd.
Saskatoon, Saskatchewan
S7N 2X8
(306) 975-5514

Potential Evapotranspiration of the Tri-Creeks Experimental Watershed

The project is designed to calculate potential evapotranspiration (ET) in a forested and cleared area of the Tri Creeks Experimental Watershed near Cadomin, Alberta. Calculated ET values are compared to literature sources and values derived from a

simple water balance equation. Perman's and Hammond's method of calculating ET are used. The study period extends from 1985-1986. Department of Forest Science, University of Alberta is a participating agency. A report will be available by January 1987.

Contact: Allen Nip
Alberta Forest Service
Forest Research Branch
215 McLeod Avenue
Spruce Grove, Alberta
T0E 2C0

The Use of NOAA Satellite Imagery for River Forecasting in Alberta

The purpose of the study is to monitor snow depletion and snowfall in the Bow River basin study region using computer-processed NOAA weather satellite imagery. Snow area statistics derived with this method are being integrated and tested in river forecast models. The study period covers May to July 1985, 1986. The project is jointly conducted by the Remote Sensing Centre and River Forecast Centre of Alberta Environment.

Contact: Steven Ferner
River Forecast Centre
Alberta Environment
9820 - 106 Street
Edmonton, Alberta
T5K 2J6
(403) 427-6278

Deviation of Storm Intensity Duration Curves for AES Radars

Weather radar was used to establish a radar-to-rainfall relationship for the purposes of analysing the intensity of Alberta rainstorms. Atmospheric Environment Service radars, located at Carvel and Vulcan, were incorporated into this study. Rainfall intensity-curves were established from these radar data.

The project, sponsored by Alberta Environment, took place from October 1985 to March 1986. Data are available from the Atmospheric Sciences Department of the Alberta Research Council. The final report will be available from the Research Management Division of Alberta Environment.

Contact: Dr. L. Wojtiw
Atmospheric Sciences Department
Natural Resources Division
Alberta Research Council
P.O. Box 8330, Station F
Edmonton, Alberta
T6H 5X2
(403) 450-5280

1.4 SOIL

Etzikom Coulee Soil and Water Quality Study

This study was initiated in response to farmers' concerns and interested government departments. Water quality and soil quality, as it relates to irrigation water quality, was assessed at two locations downstream of Crow Indian Lake. This study involves the monitoring of meteorological parameters for determining pan evaporation. Rainfall, air temperature, relative humidity, wind miles, maximum and minimum water temperature are measured.

Data were collected weekly from April to October 1984, 1985 and May to October 1986.

Contact: Ron McMullin
Conservation and Development Branch
Alberta Agriculture
Agriculture Centre
Lethbridge, Alberta
T1J 4C7
(403) 381-5338

Microclimatic Influences on Soil Moisture and Temperature in High Frequency Chinook Areas of Southern Alberta

A physically based time course simulation model has been developed to determine the microclimate parameters which effect soil moisture and thermal regimes. This model will be applied to water and tillage management systems.

The project initiated in 1984 will continue to 1988. Published papers are available from Agriculture Canada, Lethbridge.

Contact: B. Grace
Agriculture Canada, Research Station
P.O. Box 3000
Lethbridge, Alberta
(403) 327-4561

Soil Interpretations (Climate)

A project was set up to document soil climate classifications for selected soils at seven sites throughout Alberta. Soil temperature was measured 6 levels down to 200 cm, and soil moisture was measured at 5 levels down to 200 cm. These measurements were taken twice per month in the summer and once per month in the winter.

The project began in 1979 and ended in 1985. Data and reports are available from the Terrain Sciences Department of the Alberta Research Council.

Contact: A. Howard/R. Howitt
Terrain Sciences Department
Alberta Research Council
P.O. Bag 8330, Station F
Edmonton, Alberta
T6H 5X2

Climate Data Analysis

Climate data are collected from existing weather stations and from an independent station in Sherwood Park to monitor and assess frost penetration rates. Frost penetration data are obtained by portable thermistor strings located at the Genesee Power Station, Paddle River dam and two sites in Edmonton.

Data, collected since 1982, are available from Thurber Consultants Ltd.

Contact: D.W. Hill
Thurber Consultants Ltd.
10509 - 81 Avenue
Edmonton, Alberta
(403) 432-1460

Erosion Study Project

Environmental parameters such as air temperature, soil temperature, precipitation, wind, relative humidity, and radiation are monitored at 12 stations in eastern Alberta. The purpose of this study is to look at the influence of the climate on the process of soil erosion and redistribution on agricultural landscapes.

Data have been monitored since 1985 and is available from the Terrain Sciences Department of the Alberta Research Council.

Contact: R. Howitt
Terrain Sciences Department
Alberta Research Council
P.O. Bag 8330, Station F
Edmonton, Alberta
T6H 5X2

Breton Plots

A fully automated agrometeorological station is operated in Breton, Alberta (NE25-47-4-W5). Parameters measured include pan evaporation, windspeed, direction, precipitation, soil temperatures from the surface to 1.0 metre under grass, grain and fallow. Global radiation, air temperature and relative humidity are also recorded. These data are used in a number of educational projects as well as research projects dealing with fertility studies, water balance studies and soil erosion.

The data start in 1985 and are now being computerized.

Contact: Jeff Thurston
Department of Soil Science
University of Alberta
Edmonton, Alberta
or contact the Ellerslie Research Station
(403) 988-5454

1.5 AGRICULTURE/WILDLIFE

Fire Management Plan, Elk Island National Park

Fire weather index data are used as one component in a plan which provides direction on the control and use of fire in Elk Island National Park. This plan includes a detailed ecological description of the park and discusses fire management potential of prescribed burning and its effects on vegetation and range management.

The plan is being developed between June 1986 and January 1987. Data are available from Environment Canada.

Contact: Superintendent
Environment Canada - Parks
Elk Island National Park
Site 4, R.R. 1
Fort Saskatchewan, Alberta
(403) 998-3781

Dynamics of the Parkland Grazing System

Climate data is being used to investigate the parkland grazing system to determine carrying capacity, optimum species mix, and range manipulation for the Elk Island National Park Range Management Plan.

The project is taking place from 1984 to 1986. Thesis and Management Plan should be available in the fall of 1986.

Contact: J.N. Willman
Chief Park Warden
Elk Island National Park
Site 4, R.R. 1
Fort Saskatchewan, Alberta
(403) 998-3781

or

Dr. R. Hudson
Professor of Wildlife Productivity and Management
Department of Animal Science
Room 310, AgFor Building
Edmonton, Alberta

Remote Sensing of Winter Wildlife Range

Snow-free sites were determined with Landsat satellite imagery in the Rocky Mountains west of Calgary. These snow-free sites were used in a study of the effects of climate on the landscape in winter range areas.

The study took place between April 1979 and July 1980. The final report and abridgement are available from the Remote Sensing Centre of Alberta Environment.

Contact: Ian Sutherland
Applications Section
Alberta Remote Sensing Centre
Alberta Environment
Edmonton, Alberta
(403) 427-2381

Crop Response to Fertilizer Nitrogen and Moisture

Fertilizer nitrogen application and moisture parameters are being used to develop a crop response model to predict crop yield. This model will be incorporated into the Soil Test Recommendation system.

The period of the study is from December 1984 to December 1986. A report will be available in June of 1987 from Alberta Agriculture.

Contact: L.M. Kryzanowski
Soil Specialist
Alberta Agriculture
905 O.S. Longman Building
6909 - 116 Street
Edmonton, Alberta
T6H 4P2
(403) 436-9150

Climate Inventory - Peace River Region

Daily temperature, daily and monthly precipitation, and soil temperatures are used for an agroclimate evaluation for land disposition.

The study has been ongoing since 1979. Data are available from Alberta Forestry, Lands and Wildlife.

Contact: C. McGregor
Alberta Forestry, Land and Wildlife
9945 - 108 Street
Edmonton, Alberta
T6H 3R6

1.6 FORESTRY

Flash Density Maps for Alberta

On the basis of an automated lightning detection system, a lightning flash density analysis is being prepared for Alberta on an annual basis.

TransAlta Utilities participated in this study.

Contact: Nick Nimchuk
Alberta Forest Service
10625 - 120 Street
Edmonton, Alberta
(403) 427-7344

Comparison of One Minute and Ten Minute Windspeeds for Forestry Operations

Remote Automated Weather Stations are programmed to report one minute and 10-minute mean winds. The 10-minute

mean is widely used in Fire Weather Index calculations. An attempt will be made to evaluate the error using a one minute mean.

These data are collected on an ongoing basis during the fire season. An internal report will be available in 1987.

Canadian Forestry Service participates in this study.

Contact: Ben Janz
Alberta Forest Service
10625 - 120 Avenue
Edmonton, Alberta
T5E 2S9
(403) 427-7344

Fire Incidence Analysis

Lightning fire incidence is being evaluated on the basis of the number of lightning flashes and fuel moisture. The fire weather indices are being used to evaluate fuel moisture. This study is ongoing during the fire season.

An interim report will be available in 1987.

Contact: Terry Van Nest
Alberta Forest Service
10625 - 120 Avenue
Edmonton, Alberta
T5E 2S9

Affect of Weather and Climate on Area of Forest Burned

Using computer-based fire-growth models, the area burned in the absence of fire control activity is estimated. Data required includes actual fire location, dates and times and growth based on indices from actual weather. The study area comprised northern Alberta. The study is based on data from the 1968 to 1982 fire seasons.

The report is available as a University of British Columbia thesis entitled "Methods for Evaluating the Effects of Forest Fire Management in Alberta."

The Alberta Forest Service was a participating agency.

Contact: P.J. Murphy
Department of Forest Science
Faculty of Agriculture and Forestry
University of Alberta
Edmonton, Alberta
T6G 2P5
(403) 432-4931

2. MONITORING

2.1 ENERGY

Passive Solar Monitoring of the Dwornik House at Lethbridge and the Bamford House at Edmonton

In conjunction with the Solar Energy Program, a performance evaluation of two passive solar houses in Alberta has been completed. Hourly data were obtained for total solar radiation in the horizontal plane, ambient outdoor temperatures, wind speed, wind direction, and several indoor temperatures.

Data were collected at the Dwornik House in Lethbridge from December 1983 to December 1984 and at the Bamford House in Edmonton from December 1984 to

December 1985. The final report is available from CISTI/ NRC in Ottawa.

Contact: Dave Whitten or Hubert Taube
FMS Lavalin
608, Guardian Building
10240 - 124 Street
Edmonton, Alberta
T5N 3W6
(403) 482-7341

Mountain Spring Solar Energy Monitoring Program

In conjunction with the Solar Energy Program, a performance evaluation of an active solar energy system in Edmonton was completed. A continuous record of five-minute data was collected for total solar radiation in the horizontal, 50°, and 40° plane, diffuse solar radiation in the 50° plane, ambient outdoor temperatures, wind speed, wind direction and several indoor temperatures.

The study took place from December 1981 to April 1985. A final report is available from CISTI/NRC in Ottawa.

Contact: Hubert Taube
FMS Lavalin
608, Guardian Building
10240 - 124 Street
Edmonton, Alberta
T5N 3W6
(403) 482-7341

Air and Water Monitoring for Coal-Fired Generating Stations

Continuous wind speed, wind direction and water temperature data are collected at two generating stations in Alberta. Wind speed and wind direction data are collected at one additional site.

Most of the data have been collected since the mid 1970s. Data are available through Alberta Environment, Pollution Control Division and monthly reports are available from Alberta Power.

Contact: Mr. R.N. Briggs
Director
Pollution Control Division
Alberta Environment
9820 - 106 Street
Edmonton, Alberta
T5K 2J6

2.2 HYDROLOGY

Precipitation Quality Monitoring Program

Monthly precipitation samples are analyzed for pH and ion composition at nine sites throughout Alberta. The purpose of this project is to determine the chemical characteristics of precipitation (rain and snowfall) at different points in Alberta and to detect any changes in the precipitation chemical composition due to industrialization or long range transport.

Data have been collected from 1978 to the present. Annual reports are available from the Alberta Environmental Centre.

Contact: N. Das
Alberta Environmental Centre
P.O. Bag 4000
Vegreville, Alberta
T0B 4L0
(403) 632-6761

Rain Gauge Measurement

Daily measurements of rainfall are made at the Strathcona Refinery in Edmonton. Data may be used for storm water calculations in monthly water reports to Alberta Environment when suspended solids level in effluent is exceeded due to heavy rainfall.

Data have been collected since 20 October 1983 and are available from the Strathcona Refinery.

Rainfall information from Environment Canada is used to plan activities such as shutdowns, landfarming, lagoon repair and cleaning, and stack sampling.

Contact: P. Knettig
Esso Petroleum Canada
Strathcona Refinery
P.O. Box 1020
Edmonton, Alberta
(403) 465-8247

Alberta Wheat Pool Daily Rainfall

Daily rainfall data are collected at approximately 290 grain elevator locations throughout Alberta and northeastern British Columbia.

Data are collected from 01 May to 30 October annually and are available from the Alberta Wheat Pool head office in Calgary.

Contact: David B. McIntyre
Corporate Affairs Department
Alberta Wheat Pool
Box 2700
505 - 2nd Street, S.W.
Calgary, Alberta T2P 2P5
(403) 290-4648

Precipitation Measurement Network

Daily precipitation is collected from approximately 700 stations located throughout central Alberta. This area has borders of Calgary to the south, just south of Edmonton to the north, Rocky Mountain House to the west, and just east of Stettler to the east.

Data have been collected from 01 June to 31 August annually since 1975 and are available in digitized or hardcopy form from the Atmospheric Sciences Department of the Alberta Research Council.

Contact: Dr. L. Wojtiw
Atmospheric Sciences Dept.
Natural Resources Division
Alberta Research Council
P.O. Box 8330, Station F
Edmonton, Alberta T6H 5X2
(403) 450-5280

Sacramento Precipitation Storage Gauge Network

This project entails the measurement of long-term year-round precipitation in the forest regions in Alberta known as the "green area." Precipitation is collected in Sacramento storage gauges for hydrological purposes and forest fire index calculations.

Data have been collected since 1954. Annual summaries and computer files are available from the Alberta Forest Service, Resource Planning and Evaluation or Alberta Environment, Technical Services.

Contact: Paul Jablonski
Forest Land Use Branch and
Forest Protection Branch
Alberta Forest Service
6th floor, 9920 - 108 Street
Edmonton, Alberta T5K 2C9
(403) 427-3583

Evaporation Pan Data

Evaporation pan data are being collected at two or three locations in the Brooks area. These data are being correlated with various irrigated crops including soft and hard wheat, seed alfalfa, potatoes, yellow mustard, peas, beans, carrots, and onions.

Data have been collected since 1975 and reports are available from the Alberta Horticultural Research Centre.

Contact: R.C. McKenzie or N.F. Clark
Alberta Agriculture
Irrigation Conservation Div.
Conservation & Devel. Branch
Bag 200
Brooks, Alberta

Alberta Environment Real-Time River Forecasting Weather Data Collection Network

A network of telemetered weather stations located in the South Saskatchewan River Basin monitors hourly data which is used for flood and water supply forecasting. The South Saskatchewan River Basin includes the Oldman, Bow, and Red Deer River head waters. All stations collect precipitation data and selected stations collect other meteorological parameters such as air temperature, wind speed, wind direction, relative humidity, and snowpack water content data. The stations are telemetered using the GOES (Geostationary Operational Environmental Satellite) or conventional telephone lines.

Data have been monitored since 1976 and are available from the River Forecast Centre of Alberta Environment.

Contact: David R. Graham
River Forecast Centre
Technical Services Division
Alberta Environment
10th floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6
(403) 427-6278

Alberta Environment Snow Survey Network

A network of 111 snow courses and 14 snow pillows has been established to provide estimates of snow accumulation and depletion which are used to forecast spring runoff and water supply. Snow course surveys are usually carried out in the beginning of February, March, April, May, and June while snow pillow water equivalent measurements are taken on a continuous basis.

The network has been operating at its current status for approximately 12 years although some stations were established in the 1940s. Data are available from Alberta Environment, Technical Services Division in the Water Supply and Snow Survey Bulletin. These data are also available from Environment Canada, Atmospheric Environment Service in the publication "Snow Cover Data for Canada."

Contact: G.A. Coles
Water Survey Section
Technical Services Division
Alberta Environment
11th floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6
(403) 427-6279

Precipitation Monitoring on Provincial Grazing Reserves

Monthly precipitation totals are recorded year-round from 5 Sacramento Gauges located near Provincial Grazing Reserves throughout Alberta.

Records have been maintained since October 1981.

Contact: Alan D. Taylor
Alberta Forestry, Lands & Wildlife
Public Lands Division
Room 3001, Provincial Building
10320 - 99 Street
Grande Prairie, AB T8V 6J4
(403) 538-5263

Climatological Monitoring in Jasper National Park

Daily measurements of meteorological parameters are taken at six locations throughout the park, including one Atmospheric Environment Service station in the Jasper townsite. Temperature, relative humidity, and precipitation measurements are made at seven additional sites, and just precipitation measurements are made at two additional sites. Snowfall and weather parameters are measured at four stations for use in avalanche control and forecast.

Data are available from the Alpine Specialist's Office.

Contact: W. Pfister
Alpine Specialist
Western Regional Office
(403) 852-6155

2.3 FIRE

Daily Fire Weather Observations

Weather observations are taken twice daily between the months of April and October at 185 stations across Alberta.

Data are available from Environment Canada, Atmospheric Environment Service and the Alberta Forest Service.

Contact: Weather Section
Alberta Forest Service
10625 - 120 Avenue
Edmonton, Alberta
(403) 427-7344

500 Millibar Anomaly Relative to Fire Weather

Weather monitored on a daily basis throughout the fire season is compared with fire starts and fire behaviour.

Case studies are available from the Alberta Forest Service.

Contact: Weather Section
Alberta Forest Service
10625 - 120 Avenue
Edmonton, Alberta
(403) 427-7344

2.4 AIR QUALITY

Wind Speed and Direction

An air quality network, consisting of 6 air monitoring stations operating in the Strathcona Refinery area, has been set up to measure major pollutants, wind speed, and wind direction. The purpose of the project is to determine trends in air quality, determine effectiveness of industry air pollution control, provide data of future environmental studies, and to ensure that emissions are within regulations under the Alberta Government Clean Air Act.

The project was initiated in 1980. Hourly, daily, and monthly data are available.

Contact: P. Knettig
Esso Petroleum Canada
Strathcona Refinery
P.O. Box 1020
Edmonton, Alberta T5J 2M1
(403) 465-8247

Urban Air Quality

Three air monitoring stations located in downtown, industrial, and residential areas of Edmonton and Calgary take continuous measurements of various air pollutants occurring in the atmosphere. Some of these pollutants include carbon monoxide, ozone, oxides of nitrogen, nitrogen dioxide, sulphur dioxide, total hydrocarbons, total suspended particulates, and smoke. A network of more than 50 exposure cylinders record total sulphate and dustfall data.

Data have been collected since 1974 and are available in report form from Alberta Environment.

Contact: A. Schulz, W. MacDonald, J. Torneby
Air Quality Control Branch
Pollution Control Division
Alberta Environment
6th floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6
(403) 427-5893

2.5 AGRICULTURE

Crop Parameter Monitoring

Continuous weather observations for the purposes of monitoring the growing season, heat unit accumulation, and soil temperature are collected. These parameters are then related to crop production and winter hardiness.

Contact: Thomas R. Krahn, Director
Alberta Horticultural Research Centre
Alberta Agriculture
Bag Service 2000
Brooks, Alberta T0J 0J0
(403) 362-3391

Alberta Forage Crop Insurance Program

Approximately 5,000 daily rainfall records are provided by participating producers from May 01 to August 31. As a part of the crop insurance program These data are used for the development of a weather-based computer model to assess forage production in Alberta.

Contact: I.S. Selirio
Alberta Hail and Crop
Insurance Corporation
Bag Service #16
Lacombe, Alberta T0C 1S0
(403) 782-4661